Saskowski, Ronald

From: Miller, Scott
Sent: Friday, July 31, 2015 10:56 AM
To: Saskowski, Ronald
Subject: FW: Human Health Risk Concerns in the Smokey Mountain Smelters RI/FS
Attachments: Smky Mtn - Final HHRA July 2015 Rev 2 Text.pdf; 4R-1.pdf; 60R-1.pdf

Hello Ron,
Please save this to SEMS for Smokey Mountain Smelters.
Thank you,
Scott

From: Profit, Michael [mailto:Mprofit@versar.com]
Sent: Wednesday, July 29, 2015 7:33 AM
To: Miller, Scott
Cc: Austin, Janice
Subject: RE: Human Health Risk Concerns in the Smokey Mountain Smelters RI/FS

Scott,

Attached is the revised text for Rev 2. I included the whole thing because the insertion changed the page numbers. Also attached is Table 4R-1 that addresses Ofia's comment re the CT CSR citation, and Table 60R-1 that eliminates molybdenum from the groundwater COCs based on Bill O's comment. If this doesn't work for you, please let me know.

Mike

From: Austin, Janice
Sent: Wednesday, July 29, 2015 7:19 AM
To: Miller, Scott <miller.scott@epa.gov>; Profit, Michael <Mprofit@versar.com>
Subject: Re: Human Health Risk Concerns in the Smokey Mountain Smelters RI/FS

Hi Scott,

I am working on the figure changes for the proposed plan and should have to you tomorrow. Please let me know if amenable.

Janice

On Wed, Jul 29, 2015 at 3:47 AM -0700, "Miller, Scott" <Miller.Scott@epa.gov> wrote:

Hello Mike,
When can I get the updated pages to the HHRA and the updated Proposed Plan. I need those in order to finalize the Administrative Record.
Thank you,
Scott

On Jul 28, 2015, at 1:38 PM, Profit, Michael <Mprofit@versar.com> wrote:

Scott,

On behalf of Janice, please find our responses to Ofia's July 27 comments on the Final (Rev. 1) HHRA for SMS.

Mike

From: Miller, Scott <miller.scott@epa.gov>
Sent: Monday, July 27, 2015 11:07 AM
Subject: Fwd: Human Health Risk Concerns in the Smokey Mountain Smelters RI/FS
To: Austin, Janice <jaustin@versar.com>
Cc: Kestle, Rusty <kestle.rusty@epa.gov>

Hello Janice,
Please have Mike make these minor revisions to the HHRA.
Thank you,
Scott

Begin forwarded message:

From: "Hodoh, Ofia" < Hodoh.Ofia@epa.gov>
Date: July 27, 2015 at 10:27:58 AM EDT
To: "Miller, Scott" < Miller.Scott@epa.gov>
Subject: RE: Human Health Risk Concerns in the Smokey Mountain Smelters RI/FS

Scott, listed below are my comments after reviewing the revised HHRA.

1) Mercury should be included as a vapor intrusion COPC with a target groundwater VISL at 0.67 ug/L. Please revise the text in Section 5.4, and corresponding tables.

2) Table 4R, please provide a brief explanation in the footnotes for the term "CT RSR", in the column under Potential ARAR/TBC Source.

Ofia Hodoh, M.S.
U.S. Environmental Protection Agency
Region 4
Superfund Division
61 Forsyth Street, S.W.
Atlanta, GA 30303
404.562.9176 (Office)
404.562.8842 (FAX)
hodoh.ofia@epa.gov

From: Miller, Scott
Sent: Thursday, July 23, 2015 6:43 AM
To: Hodoh, Ofia
Subject: Human Health Risk Concerns in the Smokey Mountain Smelters RI/FS

Good morning, Ofia,
Hope that you are doing well. Could you drop me an email letting me know that we have resolved the concerns that you had previously on the Smokey Mountain Smelters RI/FS in the updated RI/FS?

Thank you,
Scott Miller
Remedial Project Manager
Superfund Restoration & Sustainability Section
U.S. EPA Region 4
61 Forsyth Street, SW
Atlanta, GA 30303
(404) 562-9120
fax: (404) 562-8896

<SMS Response to July 27 EPA comments on revised HHRA.pdf>

FINAL (Revision 2)
HUMAN HEALTH RISK ASSESSMENT

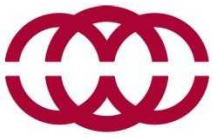
SMOKEY MOUNTAIN SMELTERS
KNOX, KNOX COUNTY, TENNESSEE

PREPARED FOR:

U.S. ENVIRONMENTAL PROTECTION AGENCY

REMEDIAL ACTION CONTRACT II LITE
REGION 4
EPA CONTRACT NO. EP-S4-08-03
TASK ORDER 019
DOCUMENT CONTROL NO.: 019HHRA071515-Final (Revision 1)

PREPARED BY:



J. M. WALLER® ASSOCIATES, INC.

MANAGING THE VISION®

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July 2015

FINAL (Revision 2)
HUMAN HEALTH RISK ASSESSMENT

SMOKEY MOUNTAIN SMELTERS
KNOX, KNOX COUNTY, TENNESSEE

Prepared for:

U.S. Environmental Protection Agency, Region 4
Remedial Action Contract II Lite
Contract No. EP-S4-08-03
Task Order 019
DCN: 019HHRA071515-Final (Revision 2)

Prepared by:

J. M. Waller Associates, Inc.

JULY 2015

Janice D. Austin, P.E. J.M. Waller Project Engineer	07/29/15 Date	Arnold Ostrofsky, P.E. J.M. Waller Program Manager	07/29/15 Date

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Acronyms and Abbreviations

ABS_{GI}	fraction of contaminant absorbed in the gastrointestinal tract
ADAF	age dependent adjustment factors
ADD	average daily dose
AF	adherence factor
AI	adequate intake
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
BCA	bias-corrected accelerated
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
BW	body weight
CA	air concentration
CLT	central limit theorem
cm^2	square centimeter
COPC	contaminant of potential concern
CSF	cancer slope factor
CSF_d	dermal cancer slope factor
CSF_o	oral cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
DA_{event}	absorbed dose per event
E	inhalation exposure per shower

Acronyms and Abbreviations

EA	exposure area
ED	exposure duration
EF	exposure frequency
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EV	event frequency
FI	fraction ingested
ft	feet
g/day	grams per day
GI	gastrointestinal tract
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic model
IR	inhalation rate
IRF	fish ingestion rate
IRIS	integrated risk information system
IRS	soil ingestion rate
IRW	water ingestion rate
JMWA	J.M. Waller and Associates
kg	kilogram

Acronyms and Abbreviations

KM	Kaplan-Meier
L/min	liters per minute
L/day	liter/day
LADD	lifetime average daily dose
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
mg/cm^2	milligrams per square centimeter
mg/day	milligrams per day
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mg^3/kg	cubic milligrams per kilogram
MOA	mode of action
MRL	minimal risk level
MVUE	minimum variance un-biased estimators
NCEA	National Center for Environmental Assessment
ND	non-detect
NHL	non-Hodgkin's lymphoma
PAHs	polycyclic aromatic hydrocarbons
PAR	pathway analysis report
PCB	polychlorinated biphenyl

PEF	particulate emission factor
PPRTV	provisional peer review toxicity values
QAPP	quality assurance project plan
RAGS	Risk Assessment Guidance for Superfund
RDA	recommended daily allowance
RfC	reference concentration
RfD_d	dermal reference dose
RfD_o	oral reference dose
RGO	remedial goal option
RME	reasonable maximum exposure
RSL	regional screening level
SA	exposed skin surface area
SMS	Smokey Mountain Smelters
SVOC	semi-volatile organic compound
t_{event}	event frequency
TCDD	tetrachlorodibenzo-p-dioxin
TCE	trichloroethene
TEQ	toxic equivalency
THQ	target hazard quotient
TR	target risk
UCL	upper confidence limit
URF	unit risk factor

Acronyms and Abbreviations

VOC	volatile organic compound

1. INTRODUCTION

J.M. Waller and Associates, Inc. (JMWA) was tasked by the U.S. Environmental Protection Agency (EPA) to perform a human health risk assessment (HHRA) for Smokey Mountain Smelters (SMS) in Knoxville, Knoxville County, Tennessee. The risk assessment was performed under Contract No. EP-S4-08-03, Task Order No. 19.

As shown in Figure 1-1 (Facility Location), SMS is located at 1508 Maryville Pike in Knoxville, Knox County, Tennessee, in the eastern portion of the state. The 13-acre property is bordered by mixed residential and commercial properties to the north; the Montgomery Village apartment complex situated approximately 200 feet (ft) to the east; an undeveloped wooded area to the south; and both residential and commercial properties to the west. In addition, active railroad lines, owned by Norfolk-Southern and CSX Transportation border the property to the east and west, respectively. The majority of the residential areas that border SMS are low density with large areas that are wooded and undeveloped. Figure 1-2 shows the overall facility layout.

The HHRA was developed to characterize the potential exposure and risks associated with exposure to contaminants of potential concern (COPCs) at the SMS Site (the Site). The HHRA was based on the receptors and exposure parameters presented in the Pathways Analysis Report (PAR) (JMWA, 2012), and considers the current and future-use exposure pathways by which individuals may be exposed to contaminated media. Exposure pathways were identified based on consideration of the sources and locations of contaminants, the likely environmental fate of the contaminants, and the location and activities of the potentially exposed populations.

During the preparation of this HHRA, the JMWA team reviewed the available information pertaining to the Site. Members of the JMWA team also visited the Site to gain a firsthand understanding of potential human exposures. This information was applied to the development of the PAR and the exposure assessment presented in this document.

The HHRA was developed in accordance with EPA Guidance set forth in the following documents:

- Specific risk assessment guidance from EPA Region 4.

- *Risk Assessment Guidance for Superfund (RAGS): Human Health Evaluation Manual, Part A* (EPA, 1989).
- *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* (EPA, 1991).
- *Guidelines for Exposure Assessment* (EPA, 1992).
- *Exposure Factors Handbook: 2011 Edition* (EPA, 2011a).
- *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part D* (EPA, 2001).
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (EPA, 2002).
- *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment. Final* (EPA, 2004).
- *Child-Specific Exposure Factors Handbook* (EPA, 2008).
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment. Final* (EPA, 2009a).
- *Draft Final Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins* (EPA, 2014a).
- *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors* (EPA, 2014b).

1.1 REPORT OVERVIEW

There are five major components of the HHRA process for the SMS Site:

- Hazard Identification – Describes the available site data, the data usability and validation, and the guidelines for data reduction for risk assessment purposes; outlines the data evaluation approach; and identifies the COPCs (Section 2);

- Toxicity Assessment – Describes and identifies the cancer and noncancer toxicity factors that were used to evaluate the risks associated with exposure to COPCs (Section 3);

- Exposure Assessment – Describes the exposure setting and local land and water uses. Presents a conceptual site model (CSM) for human exposures that describes the source of contamination, the affected media, and the exposure scenarios and their associated exposure pathways. Methods for estimating the exposure point concentrations (EPCs) are also presented along with the scenario-specific exposure parameters (Section 4);

- Risk Characterization – Integrates the toxicity assessment and the exposure assessment to characterize potential cancer risks and noncancer health effects and presents an overall summary of the potential risks based on exposure to the affected media (Section 5); and

- Uncertainty Analysis – Identifies the important uncertainties in the risk assessment process and describes the potential impact of these uncertainties on the overall estimate of risk (Section 6).

2. HAZARD IDENTIFICATION

The hazard identification presents the data available to assess site risks, outlines the approach used to summarize the data, and identifies the COPCs. The hazard identification process involves the following tasks:

- Review of available data;

- Evaluation of the data usability and data validation;

- Establishment of guidelines for data reduction;

- Evaluation of data for use in the risk assessment; and

- Selection of the COPCs.

2.1 REVIEW AVAILABLE DATA

Due to interim remedial measures, the historical data is no longer reflective of current site conditions and was therefore not incorporated in the HHRA. Additionally, as presented in the *Final Trip Report, Integrated Assessment Sampling Event* (Tetratech, 2009), volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) within the apartment complex and waste piles soil samples were either not detected or detected at levels below the EPA RSL. Therefore, it was determined that further characterization of VOCs and SVOCs in the areas outside of the capped areas was not necessary. Therefore, there is no VOC and SVOC data for these on-site areas included in the HHRA. It was assumed that these areas pose no risk from VOC and SVOC contaminant exposure to human health. Furthermore, data within the capped areas (i.e.,

subsurface soil) is included in the HHRA in order to fully characterize the human health risks at the SMS site. The uncertainties associated with these assumptions are discussed below in Section 6.

2.2 DATA USABILITY AND DATA VALIDATION

Data usability is defined as the process of ensuring that the quality of the data meets the intended use. Data usability involves assessing the analytical quality, sampling methodology, and field errors that may be inherent in the data. Factors evaluated include the level of validation and data quality indicators such as completeness, comparability, precision and accuracy, and analytical detection limits. All data were reviewed in accordance with the approved project Quality Assurance Project Plan (QAPP) (JMWA, 2011).

As per longstanding EPA risk assessment guidance (e.g., the 1989 Risk Assessment Guidance for Superfund, Volume I – Human Health Evaluation Manual (Part A) page 5-15 and the 1992 Guidance for Data Useability in Risk assessment (Part A) page 113), J-qualified concentrations are used the same way as unqualified data within a dataset. Although there are reliability issues with J-qualified values, for risk assessment purposes, they are used as-is at the qualified concentration with the appropriate weight given to the value in any conclusions and subsequent decision-making process. The most important uncertainties associated with the use of J-qualified data include: 1) potentially eliminating a chemical as a COPC when it should be evaluated, if the maximum positive detection is J-qualified and the value is estimated low; and 2) potentially retaining a chemical as a COPC when it should be eliminated if the maximum positive detection is J-qualified and the value is estimated high. Data validation reports are presented in the draft RI/FS report (JMWA, 2015).

2.3 GUIDELINES FOR DATA REDUCTION

The following guidelines for data reduction were used to produce the data summaries for the soil, groundwater, fish tissue, surface water, and soil gas evaluated in the HHRA. These approaches are consistent with *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation (Part A)* (EPA, 1989).

- If an analyte was not positively identified in any sample in a given medium, because it was reported as a non-detect (indicated by a "U" qualifier), because it was present as a result of blank contamination, or because it was rejected by the data validator (indicated by an "R" qualifier), it was not addressed in that medium.
- All analytical data with "J" qualifiers were assumed to be positive identifications. "J" indicates that the numerical value is an estimated concentration (e.g., is reported below the minimum confident detection limit).
- The treatment of field duplicates was as follows to arrive at the appropriate sample measurement for use in the HHRA:
  - If both samples (primary and field duplicate) indicated that the analyte was detected, the maximum of the two detected concentrations was used in the HHRA;
  - If both samples were non-detect (ND), the maximum of the sample quantitation limits was used in the HHRA; and
  - If one sample was detected and the other was ND, the detected concentration was used in the HHRA.

2.4 DATA EVALUATION

The data evaluation summarizes the available soil, groundwater, fish tissue, surface water, and soil gas data for use in the HHRA. The summary tables present the following information:

- List of detected contaminants.
- Range of detected concentrations.
- Locations of maximum detected concentrations.
- Frequency of detection.
- Range of detection limits.
- Screening toxicity values.
- Whether or not the compound is a COPC and the reason for selection or deletion.

Summaries for two soil data groupings were presented: one for the surface soil (0 to 1 ft below ground surface [bgs]) and one for the surface/subsurface soil (0 to 10 ft bgs), hereafter referred to as "total soil." Surface soil data were used to evaluate those receptors that are not expected to routinely contact soil at a depth greater than 1 ft bgs. Total soil data were used to evaluate future construction workers who may contact the total soil as a result of the mixing of soils from 0 to 10 ft bgs, which may occur during construction activities.

Tables 1R (surface soil) and 2R (total soil) present the data summaries for both the on-site and Flenniken Branch soils. Detected analytes include pesticides, polycyclic aromatic hydrocarbons (PAHs), dioxin/furans, polychlorinated biphenyl (PCB) compounds, and inorganics.

Table 3R presents the data summaries for groundwater. Detected analytes include VOCs, SVOCs, and inorganics.

Table 4R presents the data summaries for fish tissue (carp, largemouth bass, and all species combined) collected from Knob Creek. Detected analytes include one VOC (benzaldehyde), dioxin/furans, PCBs, and inorganics.

Table 5 presents the data summaries for soil gas collected on-site. Detected analytes include thirteen VOCs.

The data summary and results for the surface water evaluation for Knob Creek Embayment are presented and discussed further in Appendix A.

Figures 2-1 through 2-5 present sample locations for all of the media evaluated in the HHRA.

2.5 SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

The COPC selection process was conducted to identify a subset of contaminants that were detected in the soil, groundwater, fish tissue, and soil gas that could pose a potential risk to human receptors who might contact the affected media. The COPC screening process was conducted in accordance with EPA Region 4 guidance (EPA, 2014a). The criteria that were used to determine if a contaminant was a COPC included:

- Non-detection - if a contaminant was not detected in any samples, it was not evaluated as a COPC.
- A comparison of the maximum detected concentrations to health-based screening criteria - The EPA Regional Screening Levels (RSLs) (EPA, 2015a) were used as the screening criteria to select COPCs. For screening purposes, a target hazard quotient (THQ) for noncancer based RSLs of 0.1 was used. This was done to account for the potential additive effects of multiple contaminants impacting similar target organs. A target risk (TR) for cancer-based RSLs of one-in-a-million (expressed as $1x10^{-6}$) was used. In cases where a contaminant had cancer and noncancer criteria, the lower (i.e., more stringent) of the two values was used for COPC screening. When an analyte did not have a screening criterion available, a suitable surrogate analyte was identified and the screening value for the surrogate analyte was used in the COPC selection process. The analytes for which surrogate screening values were used are noted on the COPC screening tables. There were cases where a suitable surrogate could not be identified for an analyte and a comparison to screening criteria could not be performed. These analytes were not carried forward in the risk assessment. The uncertainty associated with not evaluating these analytes is discussed further in the Uncertainty Analysis. If the maximum detected concentration was less than the RSL, the analyte was eliminated from further consideration in the HHRA. If the maximum concentration exceeded the RSL, the contaminant was identified as a COPC. Further, any member of a contaminant class (e.g., carcinogenic PAHs) that has other members identified as COPCs was also retained as a COPC (EPA, 2014a).
    - The following presents justification for the selection of surrogate screening values:
        - Pyrene was used as a surrogate for both benzo(g,h,i)perylene and phenanthrene because its reference dose (RfD) is in the mid-range of RfDs for other non-carcinogenic PAHs, as well as structure-activity considerations.
        - For conservatism and/or for lack of chromium speciation (as is the case for soil) hexavalent chromium was selected as a surrogate for total chromium.
        - Chlordane was selected as a surrogate for gamma-chlordane due to similar structural properties.

- Methylmercury is the only form of mercury that accumulates appreciably in fish and was therefore used for the mercury screening level in fish tissue.

- Soil: The COPCs in soil were identified by comparing the maximum detected concentrations to the residential soil RSLs (EPA, 2015a).
- Groundwater: The COPCs in groundwater were identified by comparing the maximum detected concentrations to the tap water RSLs (EPA, 2015a).
- Fish Tissue: The COPCs in fish tissue were identified by comparing the maximum detected concentrations to the fish ingestion RSLs (EPA, 2014c).
- For metals considered to be essential nutrients (calcium, magnesium, potassium, and sodium), as well as conventionals presented on Table 3R, the maximum concentrations in soil and groundwater were used to calculate a maximum daily intake for children. The maximum intake levels were compared to Recommended Daily Allowances (RDAs) and Adequate Intakes (AIs). If the maximum intake of the essential nutrient was greater than the RDA or AI, it is discussed further in the Uncertainty Analysis.

2.5.1 Soil

Tables 1R and 2R present the COPC selection process for the analytes that were detected in the surface and total soil, respectively. The following table summarizes those analytes that exceeded their respective screening criteria:

Soil COPCs			
On-Site (Surface Soil)	**Flenniken Branch (Surface Soil)**	**On-Site (Total Soil)**	**Flenniken Branch (Total Soil)**
2,3,7,8-TCDD TEQ	Benzo(a)anthracene	Benzo(a)anthracene	Benzo(a)anthracene
Aluminum	Benzo(a)pyrene	Benzo(a)pyrene	Benzo(a)pyrene
Arsenic	Benzo(b)fluoranthene	Benzo(b)fluoranthene	Benzo(b)fluoranthe
Chromium	Benzo(k)fluoranthene	Benzo(k)fluoranthene	Benzo(k)fluoranthe
Cobalt	Chrysene	Chrysene	Chrysene
Copper	2,3,7,8-TCDD TEQ	Indeno(1,2,3-cd)pyrene	2,3,7,8-TCDD TEQ
Iron	Aluminum	PCB-1232	Aluminum
Manganese	Arsenic	Aluminum	Arsenic
Vanadium	Chromium	Arsenic	Chromium

Soil COPCs			
On-Site (Surface Soil)	**Flenniken Branch (Surface Soil)**	**On-Site (Total Soil)**	**Flenniken Branch (Total Soil)**
Thallium	Cobalt	Chromium	Cobalt
Zinc	Cyanide	Cobalt	Cyanide
	Iron	Copper	Iron
	Manganese	Iron	Manganese
	Thallium	Manganese	Thallium
		Thallium	
		Zinc	
		Vanadium	

Because of the carcinogenic PAH exceedances of the residential soil RSL (with the exception of on-site surface soil), all of the detected carcinogenic PAHs that did not exceed the residential RSL were also selected as COPCs (EPA, 2014a). These included benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene (on-site total soil only).

No toxicity values were available to evaluate the presence of essential nutrients (calcium, magnesium, potassium, and sodium). The presence and possible exposures to these inorganic compounds in soil were evaluated as essential dietary nutrients. The maximum intakes were compared to RDAs or AIs. The results of this comparison are presented in Table 8 and indicate that the nutrient-based reference values are substantially greater than the intake that could occur as a result of ingesting soil with the maximum detected concentrations. As a result, these compounds are unlikely to contribute significantly to total risks and no further evaluation of these compounds was performed.

2.5.2 Groundwater

Table 3R presents the COPC selection process for the analytes that were detected in groundwater. The following table summarizes those analytes that exceeded their respective screening criteria:

Groundwater COPCs	
Shallow	**Deep**
1.2.4-Trimethylbenzene	1.2-Dichloroethane
2.4-Dinitrotoluene	2.4-Dinitrotoluene
4.4-DDD	2.6-Dinitrotoluene
Benzene	Benzene
Bis(2-ethylhexyl)phthalate (BEHP)	BEHP
Bromodichloromethane	Bromomethane
Bromomethane	Chloroform
Chloroform	Dieldrin
Dibenzofuran	Heptachlor Epoxide
Dieldrin	Naphthalene
Ethylbenzene	Pentachlorophenol
Naphthalene	TCE
Pentachlorophenol	Aluminum
Phenol	Arsenic
Tetrachloroethene	Beryllium
Trichloroethene (TCE)	Cadmium
(m- and or p-)Xylene	Chromium
Aluminum	Cobalt
Antimony	Copper
Arsenic	Cyanide
Beryllium	Iron
Cadmium	Lead
Chromium	Manganese
Cobalt	Mercury
Copper	Molybdenum
Cyanide	Nickel
Iron	Selenium
Lead	Strontium
Manganese	Thallium
Mercury	Vanadium
Molybdenum	Zinc
Nickel	
Selenium	
Strontium	
Thallium	
Vanadium	
Zinc	

No toxicity values were available to evaluate the presence of essential nutrients (calcium, chloride, magnesium, potassium, and sodium) and conventionals (ammonia, chloride, fluoride, nitrate, nitrite, orthophosphate, sulfate, and sulfide). The presence and possible exposures to these compounds in groundwater were evaluated separately by comparing maximum intakes to RDAs or AIs. The results of this comparison are presented in Table 8 and indicate that the reference values for magnesium, potassium, orthophosphate, and sulfide are substantially greater than the intake that could occur as a result of ingesting groundwater with the maximum detected concentrations. As a result, these compounds are unlikely to contribute significantly to total risks and no further evaluation of these compounds was performed. However, reference values for calcium, chloride, fluoride, nitrate, nitrite, sodium, and sulfate are exceeded by site concentrations and are discussed further in the Uncertainty Analysis.

For those shallow groundwater COPCs identified as VOCs, maximum detected concentrations were compared against EPA Target Groundwater Concentrations for potential vapor intrusion concerns (EPA, 2015a) (see Table 3R). Target groundwater concentrations were derived using EPA's VISL Calculator at a TR of 1E-06 and a THQ of 1.0 last updated in May 2014 (EPA, 2014d). These values were updated to reflect those changes made in the January 2015 RSL update (EPA, 2015a).

2.5.3 Fish Tissue

Table 4R presents the COPC selection process for the analytes that were detected in fish tissue. The following table summarizes those analytes that exceeded their respective screening criteria:

Fish Tissue COPCs		
Carp	**Largemouth Bass**	**All Species**
2,3,7,8-TCDD TEQ	2,3,7,8-TCDD TEQ	2,3,7,8-TCDD TEQ
PCB Dioxin-Like Congener TEQ	PCB Dioxin-Like Congener TEQ	PCB Dioxin-Like Congener TEQ
PCB-1260	PCB-1260	PCB-1260
Arsenic	Chromium	Arsenic
Chromium	Mercury	Chromium

Fish Tissue COPCs		
Carp	**Largemouth Bass**	**All Species**
Lead		Lead
		Mercury

2.5.4 Soil Gas

Table 5 presents the COPC selection process for the analytes that were detected in soil gas. The following table summarizes those analytes that exceeded their respective screening criteria:

Soil Gas COPCs
1,1-Dichloroethane
1,2,4-Trimethylbenzene
1,2-Dichloroethane
Benzene
Chloroform
Chloromethane
Ethylbenzene

3. TOXICITY ASSESSMENT

The toxicity assessment describes and identifies the toxicity values for the COPCs used in the estimation of potential cancer risks and noncancer health effects. It also provides a description of the terms that were used to estimate toxic effects along with the applicable data sources. Summary tables (Tables 9 through 12) are included that present the toxicity values for each of the COPCs in RAGS Part D format (EPA, 2001).

3.1 CANCER EFFECTS

For cancer effects, the toxicity values are expressed as oral cancer slope factors (CSF_o) in units of per milligrams of COPC per kilogram per day $(mg/kg\text{-}day)^{-1}$ or as inhalation unit risk factors (URF) in units of per micrograms of COPC per cubic meter $(\mu g/m^3)^{-1}$. The use of a toxicity value depends on the route of exposure being evaluated. The CSF_o is used to evaluate exposure from

ingestion routes (e.g., drinking water) and the URF is used to evaluated inhalation exposures (e.g., inhaling VOCs while showering).

EPA has assigned each COPC a "weight-of-evidence" category that represents the likelihood of it being a human carcinogen (EPA, 1989). Six weight-of-evidence categories exist:

- A – Human carcinogen;
- B1 – Probable human carcinogen, limited human data are available;
- B2 – Probable human carcinogen, sufficient evidence in animals and inadequate or no evidence in humans;
- C – Possible human carcinogen;
- D – Not classifiable as to human carcinogenicity; and
- E – Evidence of non-carcinogenicity for humans.

EPA revised the weight-of-evidence categories to include the following five cancer hazard descriptors (EPA, 2005a):

- Carcinogenic to humans;
- Likely to be carcinogenic to humans;
- Suggestive evidence of carcinogenic potential;
- Inadequate information to assess carcinogenic potential;
- Not likely to be carcinogenic in humans.

COPCs that are classified in categories A through C following the 1989 weight-of-evidence classification and in the first three categories according to the 2005 classification system are generally carried through the risk characterization step if CSFs or URFs have been developed.

For carcinogens that act with a mutagenic mode of action (MOA) for carcinogenesis (e.g., trichloroethylene [TCE], vinyl chloride, and hexavalent chromium), EPA recommends application of Age-Dependent Adjustment Factors (ADAFs) to the CSF/URF to address early lifetime exposures and the increased susceptibility of children to carcinogens (EPA, 2005b). This approach was followed in the HHRA and is discussed further in Section 5.1.

3.2 NONCANCER EFFECTS

Noncarcinogens refer to contaminants that cause toxic effects other than cancer. Noncancer effects can include, for example, central nervous system damage, reproductive effects, and other systemic effects. For noncancer effects, the toxicity values are expressed as oral reference doses (RfD_o) in units of mg/kg-day and reference concentrations (RfCs) in units of milligrams per cubic meter (mg/m^3). The premise of noncancer toxicity values is that there is an exposure level below which deleterious noncancer effects are not expected to occur. As with the cancer toxicity values, the use of a noncancer toxicity value depends on the route of exposure being evaluated; the RfD_o is used to evaluate exposure from ingestion routes and the RfC is used to evaluate exposure from inhalation.

3.3 SOURCES OF TOXICITY VALUES

The toxicity values used in this risk assessment were obtained from the following sources in the order presented (EPA, 2003):

- Tier 1 – Integrated Risk Information System (IRIS) (EPA, 2015b).
- Tier 2 – EPA's Provisional Peer Review Toxicity Values (PPRTVs) as presented in the EPA RSL Table (EPA, 2015a).
- Tier 3 – Other Toxicity Values - can include the National Center for Environmental Assessment (NCEA) values presented on the RSL Table, the Health Effects Assessment Summary Tables (HEAST), California EPA values, and the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs).

3.4 DERMAL EXPOSURE

Toxicity values have not been developed for the dermal absorption pathway. Dermal toxicity values were derived from the oral toxicity values as described in EPA's dermal risk assessment guidance (EPA, 2004). In general, the CSF_os and RfD_os are expressed as administered doses (i.e., the amount of a chemical administered per unit time and weight). Conversely, exposures resulting from the dermal pathway are expressed as absorbed doses. Therefore, it is necessary to adjust the oral toxicity value to account for the contaminant-specific absorption efficiency.

The fraction of a COPC that is absorbed in the gastrointestinal tract, also known as ABS_{GI}, is a critical factor when adjusting from an administered to an absorbed dose. The ABS_{GI} values used in this risk assessment were obtained from the EPA RSL table (2015a). The CSF_os and RfD_os were adjusted to an absorbed dose using different methods. The dermal CSF (CSF_d) was derived by dividing the CSF_o by the ABS_{GI} as shown in Equation 1.

Equation 1

$$CSF_d = \frac{CSF_o}{ABS_{GI}}$$

Where:

CSF_d	=	Dermal cancer slope factor $(mg/kg\text{-}day)^{-1}$
CSF_o	=	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$
ABS_{GI}	=	Fraction of contaminant absorbed in the gastrointestinal tract (unitless)

The dermal reference dose (RfD_d) was derived by multiplying the RfD_o by the ABS_{GI} as shown in Equation 2.

Equation 2

$$RfD_d = RfD_o \times ABS_{GI}$$

Where:

RfD_d	=	Dermal reference dose (mg/kg-day)
RfD_o	=	Oral reference dose (mg/kg-day)
ABS_{GI}	=	Fraction of contaminant absorbed in the gastrointestinal tract (unitless)

3.5 LEAD

Lead was identified as a COPC in groundwater (shallow and deep). EPA has not assigned verified or provisional toxicity values (i.e., CSFs and RfDs) to lead because the toxicity data available to date are inadequate for evaluation by the current methodology. Therefore, lead risk was not evaluated using the conventional risk assessment approach. EPA's Integrated Exposure Uptake Biokinetic model (IEUBK) (EPA, 2010) was used to characterize lead risk to children, the most susceptible receptor (see Section 5.3).

4. EXPOSURE ASSESSMENT

The objective of the exposure assessment is to estimate the nature, extent, and magnitude of potential exposure of humans to COPCs considering both current and future uses. The exposure assessment involves several steps, which are listed below:

- Evaluating the exposure setting, including describing current and future land and water uses and identifying potentially exposed human populations.
- Developing the conceptual site model including sources, release mechanisms, transport and receiving media, exposure media, exposure scenarios, exposure routes, and potentially exposed populations.
- Calculating EPCs for each of the exposure scenarios and routes of exposure.
- Identifying the exposure scenarios, models, and parameters with which to calculate exposure doses.

To provide a range of exposure and risks, the reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios were evaluated (EPA, 1992). The RME, an estimate of the high-end exposure in a population, is based on a combination of average and high-end estimates of exposure parameters typically representing the 90^{th} percentile or greater of actual expected exposure. The CTE represents an estimate of the average exposure in a population and is based on central estimates of exposure parameters. Both the RME and CTE were evaluated for each exposure scenario.

4.1 EXPOSURE SETTING

4.1.1 Current and Future Land Uses

The HHRA evaluated potential risks associated with the current and reasonably anticipated future uses of SMS. Current land uses formed the basis for the evaluation of existing (i.e., baseline) conditions. Future land uses formed the basis for the evaluation of risks associated with future use of SMS.

Based on current zoning restrictions (currently zoned for commercial/industrial use), the presence of active and historical industrial properties nearby, as well as the likely future use of SMS, future residential development is unlikely. Although unlikely, it was conservatively assumed that SMS could be developed for residential or recreational purposes in the future. Therefore, an estimate of the upper-bound limits of the potential risks associated with human health was considered.

4.2 CONCEPTUAL SITE MODEL

A CSM describes the contaminant sources, the release and transport mechanisms, the receiving media, the exposure media, the exposure routes, and the potentially exposed populations. The primary objective of the CSM is to identify complete and incomplete exposure pathways. A complete exposure pathway has all of the above-listed components, whereas an incomplete pathway is missing one or more. Figure 4-1 illustrates the CSM that was developed for the SMS site as part of the *Preliminary Conceptual Site Model Technical Memorandum* (JMWA, 2012). Each component of the CSM is examined in detail in the following sections.

4.2.1 Source of Contamination, Release and Transport Mechanisms, and Receiving Media

As presented in the *Preliminary Conceptual Site Model Technical Memorandum* (JMWA, 2012), sources of contamination at SMS are related to the former operations on site, specifically the former fertilizer plant and secondary aluminum smelter operations. Specific source areas on site based on the historical data include the following: former waste pile area, former settling ponds, former transformer pad, former process building, railroad spur, and recovered underground storage tanks. Within the former process building, specific targeted source areas are the stacks and floor

drains. In addition, prior to the time-critical removal action in 2011, the stockpiles of aluminum dross and salt cake were also potential source areas.

The following release and transport processes affecting the fate and effect of contaminants within the SMS site have been identified:

- Surface runoff and drainage during and after precipitation events;
- Wind erosion;
- Leaching and infiltration to groundwater;
- Migration through the vadose zone; and
- Bioaccumulation within the food chain.

4.2.2 Exposure Areas (EAs)

Because of the various land and water uses throughout the SMS site, the HHRA was evaluated based on three separate EAs. These included the on-site EA, Flenniken Branch, and Knob Creek Embayment.

4.2.3 Primary Exposure Media

Based on the review of the current and potential land and water uses, the following primary exposure media are of potential concern to humans at the SMS site:

- Soil (on-site).
- Sediment (on-site, Flenniken Branch, and Knob Creek Embayment).
- Groundwater (on-site).
- Fish (Knob Creek Embayment).
- Soil Gas (on-site).
- Surface water (on-site, Flenniken Branch, and Knob Creek Embayment).

4.3 IDENTIFICATION OF EXPOSURE PATHWAYS

The following sections describe the possible receptors and exposure pathways considering both current and potential future land and water uses. An identified pathway does not imply that exposures are actually occurring, only that the potential exists for the pathway to be complete.

4.3.1 Soil Exposure

Direct contact with on-site surface and subsurface soil (soil ingestion and dermal absorption) and inhalation of VOCs and particulates are all potential exposure pathways for current and future populations, which include on-site workers, trespassers, recreational users, construction workers, and hypothetical future residents. Based on the anticipated future use of the SMS site, future residential development is unlikely. However, it was conservatively assumed that the SMS site could be developed for residential purposes in the future in order to estimate the upper-bound limit of the potential risks associated with human health.

4.3.2 Sediment and Surface Water Exposure

There is the potential for surface water and sediment exposure to both current and future populations at all three EAs. However, consistent with EPA Region 4 guidance, direct contact with sediment in underwater areas (e.g., Flenniken Branch and Knob Creek Embayment) was not quantitatively evaluated in the HHRA because of infrequent contact by human receptors. When sediments are in underwater areas, receptors will infrequently, if at all, come in contact with sediment. Therefore, the sediment exposure pathway was not evaluated at SMS. In order to account for portions of the year when sediments may be dry, sediments were treated as surface soil. Based on the minimum likelihood of human health exposure to surface water on-site and along Flenniken Branch, it was assumed that the surface water contact exposure scenarios for these EAs would be eliminated from consideration in the HHRA. To account for potential human health exposure to surface water in the Knob Creek Embayment, a risk-based surface water screening evaluation was conducted and is presented in Appendix A. Based on the low levels observed in the available surface water data from Knob Creek, the surface water contact exposure scenarios for this EA were also eliminated from consideration. A risk-based surface water screening evaluation supporting this decision is provided in Appendix A.

4.3.3 Groundwater Exposure

Future potable use of on-site groundwater could result in potential exposure to contaminants to a current/future on-site worker through ingestion and a hypothetical future resident through ingestion and dermal contact. If VOCs are present in the groundwater, there is the additional potential for inhalation exposure to the future on-site worker or the hypothetical future adult resident. Based on the depths of shallow groundwater samples included in the HHRA (13 ft bgs to 43 ft bgs), a construction worker would not come into direct contact with groundwater during excavation activities (typically up to 10 ft bgs). Therefore, this receptor pathway was not evaluated in the HHRA.

4.3.4 Fish Consumption

Recreational fishing in the Knob Creek Embayment is known to occur and potential fish ingestion exposure to anglers is a potential exposure pathway for current and future populations.

4.3.5 Soil Gas/Indoor Air Exposure

There is the potential for future on-site workers and hypothetical future residents to be exposed to VOCs through the inhalation of indoor air. This potential was evaluated through the evaluation of soil gas samples taken on-site.

4.3.6 Exposure Point Concentrations

EPCs are the COPC concentrations that a receptor is assumed to contact during exposure to site COPCs. The subsections below present the methods used to calculate the EPCs using EPA's ProUCL software program, Version 5.0.00 (EPA, 2013). The list below presents the process for determining the EPCs.

- If less than 8 samples were collected within a data grouping, the EPC is the maximum detected concentration. Full detection limits were used as values for the non-detected samples in these small data sets. For clarification, the full detection limits for non-detects were not incorporated in the data sets as a substitution for detected concentrations. Rather, nondetects at their full detection limits were imported into ProUCL as part of the full dataset and were treated as nondetects. ProUCL then used the detection limits in order to

use the regression on order (ROS) and Kaplan-Meier (KM) methods for estimating population parameters (i.e., mean and standard deviation). These estimations were then used to calculate the appropriate parametric or non-parametric UCL.

- If 8 or more samples were collected within a data grouping and the data set contains at least 4 detects, but the data set contains less than 50% detects, a nonparametric-based UCL EPC is considered. The nonparametric-based value is derived using either Kaplan-Meier (KM) or bootstrapping estimation procedures, unless there are fewer than 10 detects. If there are fewer than 10 detects, the bootstrapping estimates are not considered.

- If 8 or more samples were collected within a data grouping and the data set contains at least 50% detects, the appropriate distribution of the data set are determined and upper confidence limits (UCLs) EPCs are selected as guided by the ProUCL supporting documentation. If the recommended UCL exceeds the maximum detected concentration, a Chebyshev-based UCL is selected as the EPC if possible. If the Chebyshev-based UCL is still higher than maximum detected concentration, the maximum concentration is selected as the EPC.

ProUCL calculates 95% UCLs using 15 different computation methods, 5 parametric and 10 non-parametric. Parametric methods rely on the estimation of parameters (such as the mean or the standard deviation) describing the distribution of the variable of interest in the population; non-parametric methods do not. The five parametric UCL computation methods include:

- Student's-t UCL.

- Approximate gamma UCL using chi-square approximation.

- Adjusted gamma UCL (adjusted for level significance).

- Land's H-UCL.

- Chebyshev inequality based UCL (using Minimum Variance Un-biased Estimators (MVUEs) of parameters of a lognormal distribution).

The 10 non-parametric methods included in ProUCL are:

- The central limit theorem (CLT) based UCL.
- Modified-t statistic (adjusted for skewness) based UCL.
- Adjusted-CLT (adjusted for skewness) based UCL.
- Chebyshev inequality based UCL (using sample mean and sample standard deviation).
- Jackknife method based UCL.
- UCL based upon standard bootstrap.
- UCL based upon percentile bootstrap.
- UCL based upon bias - corrected accelerated (BCA) bootstrap.
- UCL based upon bootstrap-t.
- UCL based upon Hall's bootstrap.

Supporting documentation (ProUCL outputs) for the calculation of the UCLs is presented in Appendix B. The soil, groundwater, fish, and soil gas EPCs used in the HHRA are presented in Tables 13R, 14R and 15 through 17.

4.4 EXPOSURE PARAMETERS

The following sections present the exposure parameters for the receptors that were evaluated in the HHRA.

4.5 COMMON EXPOSURE PARAMETERS

This section presents the exposure parameters that were used to quantify exposure in terms of contaminant intake (exposure dose). Tables 18 through 26 present the exposure parameters for each receptor by media. The formulas used in estimating exposure intakes are also shown on these tables.

The following exposure parameters values were constant for all of the exposure scenarios:

Body Weight (BW)

The average BW values for the child (1 through 6 years) and the adult was 15 kilograms (kg) and 80 kg, respectively (EPA, 2014b). For the adolescent (7 through 16 years), the BW was 45 kg (EPA, 2008). These values were used in the RME and CTE evaluations and are constant across all scenarios.

Averaging Time (AT)

The cancer-based AT was based on a 70-year lifetime for all age groups and equates to 25,550 days (70 years x 365 days/year) (EPA, 1989). The noncancer AT for each of the scenarios was based on the receptor- and scenario-specific exposure duration (ED) in years multiplied by 365 days/year. The noncancer-based AT is constant across all of the scenarios in that it is always the ED multiplied by 365 days/year.

4.6 ON-SITE WORKER EXPOSURE PARAMETERS

Adult on-site workers may be exposed to contaminants in surface soil at the SMS site via incidental soil ingestion, dermal contact and absorption, and inhalation of VOCs and particulates released from the soil, as well as groundwater ingestion. Tables 18 through 20 present the on-site worker exposure parameters and models that were used to estimate the exposure to soil, groundwater, and soil gas.

RME

An ED value of 25 years was used in the RME evaluation for the on-site worker (EPA, 2014b). An exposure frequency (EF) of 250 days/year was used (EPA, 2014b). The on-site worker was assumed to spend 8 hours per day on-site. The default worker soil ingestion rate (IRS) of 100 milligrams per day (mg/day) was assumed (EPA, 2014b). For soil and groundwater ingestion, a fraction ingested (FI) value of 1.0 was used. This assumes that the exposed individual receives 100% of their daily soil intake while working on-site. The exposed skin surface area (SA) value was 3,470 square centimeters (cm^2) (EPA, 2014b) and assumes that the head, hands, and forearms are exposed. The soil-to-skin adherence factor (AF) value of 0.12 milligrams per square centimeter

(mg/cm^2) was assumed (EPA, 2014b). The particulate emission factor (PEF), which relates the concentration of a contaminant in soil to the concentration of dust particles in air, was assumed to be the default value of 5.7E+09 cubic meters per kilogram (m^3/kg) for the Atlanta region (climate zone VI) (EPA, 2002).

An adult water ingestion rate (IRW) of 2.5 liters per day (L/day), representing the amount of water that is ingested on a daily basis, was assumed for the RME evaluation (EPA, 2014b).

CTE

The RME values for IRS, SA, PEF, and IRW were also used for the CTE evaluation. An ED value of 12 years was used in the CTE evaluation for the on-site worker (half of the RME value) (EPA, 2002). An EF of 125 days/year was used based on professional judgment (half of the RME value). The on-site worker was assumed to spend half of the RME evaluation at 4 hours per day on-site. For soil and groundwater ingestion, a FI value of 0.5 was used. This assumes that the exposed individual receives 50% of their daily soil or groundwater intake while working on-site. The AF value of 0.02 mg/cm^2 was assumed (commercial/industrial groundskeeper) (EPA, 2004).

4.7 TRESPASSER EXPOSURE PARAMETERS

Site adolescent trespassers may be exposed to contaminants in surface soil at the SMS site via incidental soil ingestion, dermal contact and absorption, and inhalation of VOCs and particulates released from the soil. Table 21 presents the trespasser exposure parameters and models that were used to estimate the exposure to soil.

RME

Based on the assumed age range of the adolescent trespasser, an ED value of 10 years was used in the RME evaluation (EPA, 2002). An EF of 104 days/year based on exposure twice a week over the course of a year was used (EPA, 2002). The trespasser was assumed to spend 4 hours per day on-site. The adult residential IRS of 100 mg/day was assumed for the trespasser (EPA, 2014b). For soil ingestion, a FI value of 1.0 was used. The SA value was 5,900 cm^2 (EPA, 2004) and assumes that the head, hands, forearms, lower legs, and feet are exposed. The AF value of 0.07

mg/cm^2 was assumed (residential gardeners) (EPA, 2004). The PEF was assumed to be the default value of 5.7E+09 m^3/kg for the Atlanta region (climate zone VI) (EPA, 2002).

CTE

The RME values for IRS, ED, SA, and PEF were also used for the CTE evaluation. An EF of 52 days/year was used based on professional judgment (half of the RME value). The trespasser was assumed to spend half of the RME evaluation at 2 hours per day on-site. For soil ingestion, a FI value of 0.5 was used. The AF value of 0.01 mg/cm^2 was assumed (adult soccer player) (EPA, 2004).

4.8 RECREATIONAL USER EXPOSURE PARAMETERS

Child and adult recreational users may be exposed to contaminants in surface soil through incidental ingestion, dermal contact and absorption, and inhalation of VOCs and particulates released from the soil. Table 22 presents the recreational users exposure parameters and models that were used to estimate the exposure to soil.

RME

Residential EDs of 6 and 20 years were assumed for the child and adult recreational users, respectively (EPA, 2014b). The recreational users were assumed to be exposed for the 9 months of the year when the ground is not frozen or snow-covered (i.e., March through November). During these months, exposure is assumed to occur 3 days/week (assume 4.33 weeks per month). This equates to an EF of 117 days/year for the RME. The recreational users were assumed to spend 4 hours per day on-site for the RME evaluation. The child and adult IRS values (200 mg/day and 100 mg/day, respectively) for residential exposure were used in the RME evaluation for the recreational users. For soil ingestion, a FI value of 1.0 was used. The SA values of 2,690 cm^2 (assuming head, hands, forearms, lower legs, and feet are exposed) and 6,032 cm^2 (assumes head, hands, forearms, and lowerlegs are exposed) were assumed for the child and adult recreational users, respectively (EPA, 2014b). The AF values of 0.12 mg/cm^2 and 0.07 mg/cm^2 were assumed for the child and adult recreational users RME evaluation. The PEF was assumed to be the default value of 5.7E+09 m^3/kg for the Atlanta region (climate zone VI) (EPA, 2002).

CTE

The RME values for the ED (child only), SA, and PEF were also used for the CTE evaluation. A residential ED of 9 years was assumed for the adult recreational user (EPA, 2002). An EF of 58 days/year was used based on professional judgment (half of the RME value). The recreational users were assumed to spend half of the RME evaluation at 2 hours per day on-site. The CTE IRS values were assumed to be 100 mg/day and 50 mg/day for the child and adult recreational users, respectively. For soil ingestion, a FI value of 0.5 was used. The AF values of 0.04 mg/cm^2 (teen soccer player, moist conditions) and 0.01 mg/cm^2 (adult soccer player) were assumed for the child and adult recreational users CTE evaluation.

4.9 CONSTRUCTION/UTILITY WORKER EXPOSURE PARAMETERS

Construction/utility workers may be exposed to contaminants in surface and subsurface soil (total soil) at the SMS site via incidental soil ingestion, dermal contact and absorption, and inhalation of VOCs and particulates released from the soil. Table 23 presents the construction/utility worker exposure parameters and models that were used to estimate the exposure to soil.

RME

An ED value of 1 year was used in the RME evaluation for the construction/utility worker (EPA, 2002). An EF of 250 days/year was assumed (EPA, 2014b). The construction/utility worker was assumed to spend 8 hours per day on-site. The construction worker IRS of 330 mg/day was assumed (EPA, 2002). For soil ingestion, a FI value of 1.0 was used. The SA value was 3,470 cm^2 (EPA, 2014b) and assumes that the head, hands, and forearms are exposed. The 95th percentile AF value of 0.3 mg/cm^2 for construction workers was assumed (EPA, 2004). The PEF was assumed to be the default value of 5.7E+09 m^3/kg for the Atlanta region (climate zone VI) (EPA, 2002).

CTE

The RME values for ED, SA, and PEF were also used for the CTE evaluation. An EF of 125 days/year was used based on professional judgment (half of the RME value). The construction/utility worker was assumed to spend half of the RME evaluation at 4 hours per day on-site. The outdoor worker IRS of 100 mg/day was assumed for the CTE evaluation (EPA, 2002).

For soil ingestion, a FI value of 0.5 was used. The geometric mean AF value of 0.1 mg/cm^2 was assumed (EPA, 2004).

4.10 RESIDENTIAL EXPOSURE PARAMETERS

Although residential development is unlikely at the SMS site, a hypothetical future residential scenario was evaluated to determine an upper-bound estimate of the potential risks posed by chemical contamination of the site. Residents were assumed to contact surface and subsurface soil as a result of the mixing of the soil that is expected to occur during construction activities. Soil exposure pathways that were evaluated include incidental soil ingestion, dermal contact and absorption, and inhalation of VOCs and particulates released from the soil. Residential groundwater exposure was also evaluated to account for future potable groundwater use. Groundwater exposure pathways evaluated included tap water ingestion, dermal contact and absorption while showering/bathing, and inhalation of VOCs while showering (adult only). Residential exposure to VOCs through inhalation of indoor air was also evaluated. EPA's VISL Calculator was used to determine indoor air concentrations through the modeling of soil gas concentrations (EPA, 2014d). The results of these models are presented in Appendix C. Tables 24 through 26 present the exposure parameters and models that were used to estimate the residential exposure to soil and groundwater.

RME

An ED of 26 years (6 years as a child and 20 years as an adult) was assumed for the RME evaluation (EPA, 2014b). An EF of 350 days/year was assumed for the RME evaluation (EPA, 2014b). The resident was assumed to spend 24 hours per day on-site for the RME evaluation. The child and adult IRS values (200 mg/day and 100 mg/day, respectively) for residential exposure were used in the RME evaluation. For soil and groundwater ingestion, a FI value of 1.0 was used. The SA values of 2,690 cm^2 (assuming head, hands, forearms, lower legs, and feet are exposed) and 6,032 cm^2 (assumes head, hands, forearms, and lower legs are exposed) were assumed for the child and adult residents, respectively (EPA, 2014b). The AF values of 0.12 mg/cm^2 and 0.07 mg/cm^2 (residential gardeners) were assumed for the child and adult residents, respectively. The

PEF was assumed to be the default value of 5.7E+09 m3/kg for the Atlanta region (climate zone VI) (EPA, 2002).

For the RME residential exposure to groundwater evaluation, the child and adult IRWs of 0.78 L/day and 2.5 L/day were assumed, respectively (EPA, 2014b). The child and adult event frequency (EV), which represents the number of bathing/showering events per day that a receptor takes, was assumed to be once a day (EPA, 2014b). The 50th percentile SAs of 6,378 cm^2 and 20,900 cm^2 were assumed for the child and adult RME evaluations, respectively (EPA, 2014b). The child bathing time (t_{event}) of 32 minutes (0.54 hour/event) was assumed (EPA, 2014b). The RME adult showering time of 43 minutes (0.71 hour/event) was assumed (EPA, 2014b). COPC-specific values needed to calculate dermally absorbed doses were either obtained from the appropriate tables in the dermal guidance (EPA, 2004) or from the EPA RSL table (EPA, 2015a). The RME COPC-specific values along with the calculated absorbed dose per event (DA_{event}) values are presented on Table 27.

For the RME residential adult showering exposure pathway, an inhalation rate (IR) of 15 liters per minute (L/min) was assumed (Foster and Chrostowski, 1987). The inhalation exposure per shower (E) was calculated using the Foster and Chrostowski model (Foster and Chrostowski, 1987 and 2003). The exposure models and parameters used to calculate the shower exposure pathway are presented in Tables 28 through 34.

CTE

The RME values for the ED (child only), EF, IRS, SA (soil and groundwater), PEF, IRW, EV, and IR were also used for the CTE evaluation. An ED of 9 years was assumed for the adult resident (EPA, 2002). The residents were assumed to spend 16 hours per day on-site for the CTE evaluation. For soil and groundwater ingestion, a FI value of 0.5 was used. The AF values of 0.04 mg/cm^2 (teen soccer player, moist conditions) and 0.01 mg/cm^2 (adult soccer player) were assumed for the child and adult resident CTE evaluation.

For the CTE residential exposure to groundwater evaluation, the child t_{event} of 16 minutes (0.27 hours/event) was assumed (EPA, 2014b). The CTE adult showering time of 22 minutes (0.36

hours/event) was assumed (EPA, 2004). The CTE COPC-specific values along with the calculated DA_{event} values are presented on Table 35.

4.11 RECREATIONAL ANGLER EXPOSURE PARAMETERS

Adult and young child (1 through 6 years) recreational anglers may be exposed to contaminants through ingestion of fish from Knob Creek. Table 36 presents the recreational angler exposure parameters and models that were used to estimate the exposure to fish tissue.

RME

As recommended by Region 4, due to the absence of site-specific information, a default upper-bound fish ingestion rate (IRF) of 54 grams per day (g/day) was assumed (EPA, 2000). One-half (27 g/day) was assumed as a reasonable estimate of the consumption rate for the dependent child of a recreational angler. An ED of 6 and 26 years was assumed for the child and adult RME evaluations, respectively (EPA, 2014b). An EF of 350 days/year was assumed for both the child and adult anglers (EPA, 2014b). It was conservatively assumed that the recreational anglers catch and consume all of their fish from Knob Creek for the RME evaluation.

CTE

The RME values for the ED (child only) and EF were also used for the CTE evaluation. For the CTE evaluation, 50% of the RME IRF was assumed for both the child (14 g/day) and adult (27 g/day) recreational anglers. An ED of 15 years (half of the RME evaluation) was assumed for the adult recreational angler. A FI value of 0.5 was assumed for both the child and adult recreational anglers for the CTE evaluation. This assumes that the anglers receive 50% of their fish ingestion from Knob Creek.

5. RISK CHARACTERIZATION

The objective of the risk characterization is to integrate the information developed in the exposure assessment and the toxicity assessment into an evaluation of the potential risks associated with exposure to COPCs. Cancer risks were calculated for those COPCs with evidence of carcinogenicity

and for which cancer toxicity values were available. Noncancer health effects were evaluated for COPCs (i.e., including carcinogens) for which noncancer toxicity values were available.

5.1 CANCER RISK

Potential cancer risks from oral and dermal exposure were calculated by multiplying the estimated lifetime average daily dose (LADD) intake that was calculated for a COPC through an exposure route by the exposure route-specific CSF, as follows:

$$\text{Risk} = \text{LADD} * \text{CSF}$$

Where:

LADD	=	Lifetime average daily dose; intake averaged over a 70-year lifetime as mg COPC kg per day.
CSF	=	COPC- and route-specific cancer slope factor $(\text{mg kg-day})^{-1}$.

Potential cancer risks from inhalation exposure were calculated by multiplying the calculated air concentration and the URF as follows:

$$\text{Risk} = \text{CA} * \text{URF}$$

Where:

CA	=	Air concentration ($\mu g\ m^3$).
URF	=	Unit risk factor $(\mu g\ m^3)^{-1}$.

EPA's cancer risk range is an increased risk of developing cancer, based on a plausible upper-bound estimate of risk, of approximately 1-in-1,000,000 (1E-06) to 1-in-10,000 (1E-04).

Carcinogens that act with a mutagenic MOA

For carcinogens that act with a mutagenic MOA for carcinogenesis, EPA recommends application of ADAFs to cancer toxicity values to address early lifetime exposures and the increased

susceptibility of children to carcinogens (EPA, 2005b). The RSL table presents those COPCs exhibiting a mutagenic MOA for carcinogenesis.

The ADAFs for specific age-groups classes are presented below:

Age (years)	ADAF (unitless)
0 – <2	10
2 – <16	3
≥16	1

Potential RME and CTE risk to an adolescent trespasser (7-16 years) was assessed using the following:

Age (years)	Exposure Factors	Exposure Duration (years)	ADAF (unitless)
6 – <16	Adolescent	10	3

Total RME and CTE risk for adolescent trespasser exposure = Risk 6 – <16

Tables 37R and 38R present the results of the adolescent trespasser MOA calculations for RME and CTE soil exposure, respectively.

Potential RME and CTE risk to a child recreational user was assessed using the following:

Age (years)	Exposure Factors	Exposure Duration (years)	ADAF (unitless)
0 – <2	Child	2	10
2 – <6	Child	4	3

Total RME and CTE risk for child recreational user exposure = Risk $_{0-<2}$ + Risk $_{2-<6}$

Tables 39R and 40R present the results of the child recreational user MOA calculations for RME and CTE soil exposure, respectively.

RME residential lifetime exposure factors were divided into two age groupings: child – 0 to 6 years and adult – 6 to 26 years. CTE residential lifetime exposure factors were divided into two age groupings: child – 0 to 6 years and adult – 20 to 26 years. Potential RME risk to an individual resident was assessed using the following:

Age (years)	Exposure Factors	Exposure Duration (years)	ADAF (unitless)
0 – 2	Child	2	10
2 – 6	Child	4	3
6 – 16	Adult	10	3
16 – 26	Adult	10	1

Potential CTE risk to an individual resident was assessed using the following:

Age (years)	Exposure Factors	Exposure Duration (years)	ADAF (unitless)
0 – 2	Child	2	10
2 – 6	Child	4	3
20 – 26	Adult	6	1

Total RME risk for lifetime exposure = $\text{Risk}_{0-2} + \text{Risk}_{2-6} + \text{Risk}_{6-16} + \text{Risk}_{16-26}$

Total CTE risk for lifetime exposure = $\text{Risk}_{0-2} + \text{Risk}_{2-6} + \text{Risk}_{20-26}$

Tables 41R and 42 present the results of the residential MOA calculations for both soil and groundwater RME exposure, respectively. Tables 43R and 44 present the results of the residential MOA calculations for both soil and groundwater CTE exposure, respectively.

Potential RME and CTE risk to a child angler was assessed using the following:

Age (years)	Exposure Factors	Exposure Duration (years)	ADAF (unitless)
0 – <2	Child	2	10
2 – <6	Child	4	3

Total RME and CTE risk for child angler exposure = Risk $_{0-<2}$ + Risk $_{2-<6}$

Tables 45 and 46 present the results of the child angler MOA calculations for RME and CTE fish exposure, respectively.

TCE

As discussed in the IRIS *Trichloroethylene Assessment Summary* (EPA, 2013c), TCE is carcinogenic by a mutagenic MOA for induction of kidney tumors. There is also more limited evidence for non-Hodgkin's lymphoma (NHL) and liver carcinogenicity. In order to account for the mutagenic MOA for kidney tumors, EPA recommends applying ADAFs when estimating kidney cancer risks from early life exposure to TCE. However, NHL and liver cancer must also be accounted for in the cancer risk estimates. To accommodate all three carcinogenic effects, a cancer risk was derived for each age group (0 – <2, 2 – <6, 6 – <16, and 16 – <26), including adjusted kidney cancer potency values and unadjusted potency values for liver cancer and NHL. These risks were then summed across age groups to obtain the total risk for the exposure period of interest. Tables 47 and 48 present the results of the residential MOA calculations for TCE for both RME and CTE groundwater exposure, respectively.

5.2 NONCANCER HEALTH EFFECTS

Potential noncancer health effects from oral and dermal exposure were evaluated by the calculation of hazard quotients (HQs) and hazard indices (HIs). An HQ is the ratio of the average daily dose (ADD) through a given exposure route to the COPC-specific RfD. The HQ-RfD relationship is illustrated by the following equation:

$$HQ = ADD\ RfD$$

Where:

ADD	=	Average daily dose; estimated daily intake averaged over the exposure duration (mg kg-day).
RfD	=	Reference dose (mg kg-day).

The HQ for the inhalation pathway was calculated as follows:

$$HQ = CA\ RfC$$

Where:

CA	=	Air concentration ($\mu g\ m^3$).
RfC	=	Reference concentration ($mg\ m^3$).

HQs were summed to calculate HIs for each scenario. HIs were calculated for each exposure route, and a total HI was calculated based on exposure to the COPCs from exposure routes for each receptor. HIs of less than one indicate that adverse health effects associated with the exposure scenario are unlikely to occur.

5.3 LEAD EVALUATION

Risks from lead exposure are not evaluated using the same methodology as other contaminants. The IEUBK model estimates blood lead concentrations to address exposures to lead. Blood lead concentration is the most widely used index of internal lead body burdens associated with potential adverse health effects of lead. Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. Since children are a more sensitive subpopulation than adults, exposure to lead by adults in a residential scenario is not generally evaluated and the receptor of concern for this scenario is the young child. Evaluation of the young child in a residential scenario is considered protective of adults, including pregnant women; adolescents, including trespassers; and children in a less frequent exposure scenario.

including recreational visitors. It has been determined that childhood blood lead concentrations at or above 10 micrograms per deciliter (µg/dL) present risks to children's health. The EPA risk reduction goal for contaminated sites is to limit the probability of a child's blood lead concentration exceeding 10 µg/dL to 5 percent or less.

Potential residential child exposure to lead in groundwater was evaluated using EPA's IEUBK model for lead in children (EPA, 2007 and 2010). The IEUBK model is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure. Because the output of these models is a range of predicted blood lead concentrations, the average shallow and deep groundwater lead concentrations were used (20.6 micrograms per liter [µg/L] and 32.2 µg/L, respectively).

EPA's IEUBK model estimated that the geometric mean blood lead concentration among future residential children exposed to shallow and deep groundwater would be 4.083 µg/dL and 4.895 µg/dL, respectively. Appendix D presents the IEUBK lead model results for shallow and deep groundwater. These estimates are less than EPA's established level of concern of 10 µg/dL. The probability that the child's blood lead concentration exceeds 10 µg/dL is 2.8% for shallow groundwater and 6.4% for deep groundwater for future residential children. EPA's target probability is 5 percent or less. In conclusion, exposures to lead in shallow groundwater do not exceed EPA's target level of concern, whereas exposures to lead in deep groundwater slightly exceed EPA's 5% or less target of concern.

5.4 VAPOR INTRUSION

As discussed previously in Section 2.5, shallow groundwater COPCs were screened against EPA Target Groundwater Concentrations (EPA, 2014d) to evaluate potential vapor intrusion concerns for future receptors. Maximum detected concentrations exceeded their respective Target Groundwater Concentrations for 1,2,4-trimethylbenzene, benzene, bromomethane, chloroform, ethylbenzene, mercury, naphthalene, tetrachloroethene, TCE, and cyanide. Ratios for 1,2,4-trimethylbenzene, benzene, bromomethane, and naphthalene were only slightly higher than 1.0 (1.2, 1.6, 1.8, and 1.4, respectively). Ratios for chloroform, ethylbenzene, tetrachloroethene, TCE, and cyanide were slightly higher with ratios of 11.2, 2.0, 3.1, 8.3, and 2.2, respectively. However,

all of these exceedances are driven by concentrations from wells within the capped waste pile area (MW01A and MW02A). For mercury, the ratio is 14.3 based on the highest detected concentration in shallow monitoring well MW-010A, and 1.4 based on the highest detected concentration in deep monitoring well MW-07B. Neither of these wells is within 100 feet of a permanent structure. In the event that future development results in the construction of permanent structures within 100 feet of MW-010A or MW-07B, potential risks associated with possible exposure to mercury vapors evolved from groundwater should be revisited. When considered together, these results indicate that vapor intrusion in unlikely to be of concern at the SMS site. Site monitoring well locations relative to site source areas are presented on Figure 2-3.

An additional line of evidence was evaluated for the vapor intrusion pathway that included the collection of soil gas samples for evaluating potential indoor air exposure to future on-site workers and residents. This line of evidence is discussed further in Section 7.4.

5.5 RISK RESULTS

Tables 49R, 50, and 51 present summaries of the total RME and CTE cancer risks and noncancer HIs for all receptors evaluated in the HHRA. The following subsections present the cancer risks and noncancer HIs by receptor. Appendix E presents the RAGS Part D Tables 7, 9, and 10 for both the RME and CTE evaluations.

5.5.1 On-Site Worker

5.5.1.1 Soil

The total soil RME and CTE cancer risks for the on-site worker for the on-site area were within the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 1.3E-05 and 1.4E-06, respectively. The total soil RME and CTE cancer risks for the on-site worker for Flenniken Branch were within or below the EPA acceptable cancer risk range with total cancer risks of 1.0E-05 and 1.7E-06, respectively. The primary RME risk drivers were 2,3,7,8-TCDD TEQ, arsenic, and chromium.

The total soil RME and CTE noncancer HIs for the on-site worker for the on-site area were less than the noncancer benchmark with total HIs of 0.3 and 0.08, respectively. The total soil RME and

CTE noncancer HIs for the on-site worker for Flenniken Branch were less than the noncancer benchmark with total HIs of 0.2 and 0.08, respectively.

See tables E-1R and E-2R for the RAGS Part D Tables 7, E-33R and E-34R for the RAGS Part D Tables 9, and E-65R for the RAGS Part D Table 10 for the on-site worker soil evaluation.

5.5.1.2 Groundwater

The total shallow groundwater RME and CTE cancer risks for the on-site worker were above or within the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 3.1E-04 and 3.7E-05, respectively. The total deep groundwater RME and CTE cancer risks for the on-site worker were above or within the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 2.7E-04 and 3.2E-05, respectively. The primary groundwater risk drivers were 2,4-dinitrotoluene, 2,6-dinitrotoluene (deep only), BEHP, chloroform (shallow only), dieldrin, heptachlor epoxide (deep only), pentachlorophenol, aluminum (shallow only), arsenic, chromium, cobalt, manganese, and thallium.

The total shallow groundwater RME and CTE noncancer HIs for the on-site worker exceeded the noncancer benchmark with total HIs of 199 and 50, respectively. The total deep groundwater RME and CTE noncancer HIs for the on-site worker exceeded the noncancer benchmark with total HIs of 132 and 33, respectively. The primary contributors to the shallow groundwater HI exceedance were cobalt, manganese, and thallium. These COPCs contributed to the nervous system, thyroid, and hair target-organ specific exceedances. The primary contributors to the deep groundwater HI exceedances were manganese and thallium which contributed to the nervous system and hair target-organ specific exceedances.

See tables E-3 and E-4 for the RAGS Part D Tables 7, E-35 and E-36 for the RAGS Part D Tables 9, and E-66 and E-67 for the RAGS Part D Tables 10 for the on-site worker groundwater evaluation.

5.5.1.3 Soil Gas

The total soil gas RME and CTE cancer risks for the on-site worker were above the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 8.3E-04 and 1.0E-04, respectively.

The primary risk drivers were 1,1-dichloroethane, 1,2-dichloroethane, benzene, chloroform, and chloromethane.

The total soil gas RME and CTE noncancer HIs for the on-site worker were greater than the noncancer benchmark with total HIs of 15 and 2, respectively. The primary contributors to the HI exceedances were 1,2-dichloroethane and chloromethane (RME only). These COPCs contributed to the nervous system target-organ specific exceedances.

See tables E-5 and E-6 for the RAGS Part D Tables 7, E-37 and E-38 for the RAGS Part D Tables 9, and E-68 and E-69 for the RAGS Part D Tables 10 for the on-site worker soil gas evaluation.

5.5.2 Trespasser

5.5.2.1 Soil

The total soil RME and CTE cancer risks for the adolescent trespasser for the on-site area were at the low end of the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 7.1E-06 and 1.7E-06, respectively. The total soil RME and CTE cancer risks for the adolescent trespasser for Flenniken Branch were either at the low end or below the EPA acceptable cancer risk range with total cancer risks of 5.9E-06 and 1.7E-06, respectively. The primary on-site risk drivers were arsenic and chromium.

The total soil RME and CTE noncancer HIs for the adolescent trespasser for the on-site area were less than the noncancer benchmark with total HIs of 0.3 and 0.06, respectively. The total soil RME and CTE noncancer HIs for the adolescent trespasser for Flenniken Branch were less than the noncancer benchmark with total HIs of 0.2 and 0.04, respectively.

See tables E-7R and E-8R for the RAGS Part D Tables 7, E-39R and E-40R for the RAGS Part D Tables 9, and E-70R and E-71R for the RAGS Part D Tables 10 for the trespasser evaluation.

5.5.3 Recreational User

5.5.3.1 Child

5.5.3.1.1 Soil

The total soil RME and CTE cancer risks for the child recreational user for the on-site area were within the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 4.3E-05 and 5.4E-06, respectively. The total soil RME and CTE cancer risks for the child recreational user for Flenniken Branch were within or below the EPA acceptable cancer risk range with total cancer risks of 3.4E-05 and 5.4E-06, respectively. The primary risk drivers were 2,3,7,8-TCDD TEQ benzo(a)pyrene, arsenic, and chromium.

The total soil RME and CTE noncancer HIs for the child recreational user for the on-site area were 2 and 0.2, respectively. The total soil RME and CTE noncancer HIs for the child recreational user for Flenniken Branch were 1 and 0.2, respectively. Although the on-site RME HI exceeded the noncancer benchmark, none of the individual COPCs had a total HQ greater than 1.

See tables E-9R and E-10R for the RAGS Part D Tables 7, E-41R and E-42R for the RAGS Part D Tables 9, and E-72R and E-73R for the RAGS Part D Tables 10 for the recreational child evaluation.

5.5.3.2 Adult

5.5.3.2.1 Soil

The total soil RME and CTE cancer risks for the adult recreational user for the on-site area were either within or below the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 4.8E-06 and 3.2E-06, respectively. The total soil RME and CTE cancer risks for the adult recreational user for Flenniken Branch were either at the low end or below the EPA acceptable cancer risk range with total cancer risks of 2.6E-07 and 1.7E-07, respectively. The primary RME risk drivers were arsenic and chromium.

The total soil RME and CTE noncancer HIs for the adult recreational user for the on-site area were less than the noncancer benchmark with HIs of 0.2 and 0.02, respectively. The total soil RME and CTE noncancer HIs for the adult recreational user for Flenniken Branch were less than the noncancer benchmark with HIs of 0.1 and 0.01, respectively.

See tables E-11R and E-12R for the RAGS Part D Tables 7, E-43R and E-44R for the RAGS Part D Tables 9, and E-74R for the RAGS Part D Table 10 for the recreational adult evaluation.

5.5.4 Construction/Utility Worker

5.5.4.1 Soil

The total soil RME and CTE cancer risks for the construction utility worker for the on-site area were within or below the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 1.8E-06 and 1.5E-07, respectively. The total soil RME and CTE cancer risks for the construction utility worker for Flenniken Branch were below the EPA acceptable cancer risk range with total cancer risks of 1.1E-06 and 9.1E-08, respectively.

The total soil RME and CTE noncancer HIs for the construction utility worker for the on-site area were equal to or less than the noncancer benchmark with HIs of 1 and 0.08, respectively. The total soil RME and CTE noncancer HIs for the construction utility worker for Flenniken Branch were less than the noncancer benchmark with HIs of 0.8 and 0.2, respectively.

See tables E-13R and E-14R for the RAGS Part D Tables 7, and E-45R and E-46R for the RAGS Part D Tables 9 for the construction utility worker evaluation.

5.5.5 Resident

5.5.5.1 Soil

The total surface soil RME and CTE cancer risks for the age-adjusted resident for the on-site area were slightly above or within the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 1.6E-04 and 6.7E-05, respectively. The total soil RME and CTE cancer risks for the age-adjusted resident for Flenniken Branch were within the EPA acceptable cancer risk range with total cancer risks of 1.4E-04 and 5.1E-05, respectively. The primary risk drivers were benzo(a)pyrene, 2,3,7,8-TCDD TEQ, arsenic, and chromium.

The total surface soil RME and CTE noncancer HIs for the child resident for the on-site area were 5 and 2, respectively. The total soil RME and CTE noncancer HIs for the child resident for Flenniken Branch were 4 and 2, respectively. Although the on-site RME and CTE HIs exceeded the noncancer benchmark, none of the individual COPCs had a total HQ greater than 1. The

primary contributor to the total RME HI at Flenniken Branch was thallium, which contributed to a target-organ specific exceedance for hair.

The total soil RME and CTE noncancer HIs for the adult resident for the on-site area were 0.5 and 0.2, respectively. The total soil RME and CTE noncancer HIs for the adult resident for Flenniken Branch were 0.4 and 0.2, respectively.

See tables E-15R through E-20R for the RAGS Part D Tables 7, E-47R through E-52R for the RAGS Part D Tables 9, and E-75R through E-77R for the RAGS Part D Tables 10 for the residential soil evaluation.

5.5.5.2 Groundwater

The total shallow groundwater RME and CTE cancer risks were above the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 1.4E-03 and 3.7E-05, respectively. The total deep groundwater RME and CTE cancer risks were above the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 1.7E-03 and 6.5E-04, respectively. The primary shallow groundwater risk drivers were 2,4-dinitrotoluene, BEHP, chloroform, dieldrin, pentachlorophenol, trichloroethene, arsenic and chromium and the primary deep groundwater risk drivers were 1,2-dichloroethane, 2,4-dinitrotoluene, 2,6-dinitrotoluene, BEHP, dieldrin, heptachlor epoxide, pentachlorophenol, arsenic, and chromium.

The total shallow groundwater RME and CTE noncancer HIs for child resident exceeded the noncancer benchmark with total HIs of 487 and 245, respectively. The total deep groundwater RME and CTE noncancer HIs for the child resident exceeded the noncancer benchmark with total HIs of 345 and 180, respectively. The primary contributors to the shallow groundwater HI exceedances were BEHP, aluminum, arsenic, cobalt, manganese, mercury, molybdenum, nickel, thallium, and zinc. These COPCs contributed to target-organ specific exceedances for blood, liver, kidney, body weight, nervous system, skin, thyroid, and hair. The primary contributors to the deep groundwater HI exceedances were BEHP, arsenic, cobalt, manganese, molybdenum, and thallium which also contributed to target-organ specific exceedances for nervous system, blood, liver, skin, thyroid, and hair.

The total shallow groundwater RME and CTE noncancer HIs for adult resident exceeded the noncancer benchmark with total HIs of 296 and 148, respectively. The total deep groundwater RME and CTE noncancer HIs for the adult resident exceeded the noncancer benchmark with total HIs of 211 and 109, respectively. The primary contributors to the shallow groundwater HI exceedances were BEHP, aluminum, arsenic, cobalt, manganese, nickel, thallium, and zinc. These COPCs contributed to target-organ specific exceedances for blood, liver, body weight, nervous system, skin, thyroid, and hair. The primary contributors to the deep groundwater HI exceedances were BEHP, cobalt, manganese, molybdenum, and thallium which also contributed to the target-organ specific exceedances for nervous system, liver, thyroid, blood, and hair.

See tables E-21through E-26 for the RAGS Part D Tables 7, E-53 through E-58 for the RAGS Part D Tables 9, and E-78 through E-83 for the RAGS Part D Tables 10 for the residential groundwater evaluation.

5.5.5.3 Soil Gas

The total soil gas RME and CTE cancer risks for the age-adjusted resident were above the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 3.6E-03 and 1.4E-03, respectively. The primary risk drivers were 1,1-dichloroethane, 1,2-dichloroethane, benzene, chloroform, chloromethane, and ethylbenzene.

The total soil gas RME and CTE noncancer HIs for the resident were 63 and 24, respectively. The primary contributor to the total RME HI was 1,2-dichloroethane and chloromethane, which contributed to target-organ specific exceedance for nervous system.

See tables E-27 and E-28 for the RAGS Part D Tables 7, E-59 and E-60 for the RAGS Part D Tables 9, and E-84 and E-85 for the RAGS Part D Tables 10 for the residential soil evaluation.

5.5.6 Recreational Angler

5.5.6.1.1 Fish Tissue

5.5.6.2 Child

The total fish RME cancer risks for the child angler for Knob Creek were greater than the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 1.8E-03 (carp), 3.8E-04 (largemouth bass) and 1.7E-03 (all species). The total fish CTE cancer risks for the child angler for Knob Creek were greater than or within the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 4.6E-04 (carp), 9.5E-05 (largemouth bass) and 4.2E-04 (all species). The primary risk drivers were 2,3,7,8-TCDD TEQ, PCB dioxin-like congener TEQ, PCB-1260, arsenic, and chromium for carp, 2,3,7,8-TCDD TEQ, PCB dioxin-like congener TEQ, PCB-1260, and chromium for largemouth bass, and 2,3,7,8-TCDD TEQ, PCB dioxin-like congener TEQ, PCB-1260, arsenic, and chromium for all species.

The total fish RME noncancer HIs for the child angler for Knob Creek were greater than the noncancer benchmark with HIs of 119 (carp), 15 (largemouth bass), and 122 (all species). The total fish CTE noncancer HIs for the child angler for Knob Creek were greater than the noncancer benchmark with HIs of 30 (carp), 4 (largemouth bass), and 31 (all species). The primary contributors to the total HI were 2,3,7,8-TCDD TEQ and PCB dioxin-like congener for carp, 2,3,7,8-TCDD TEQ, PCB Dioxin-like Congener TEQ, and mercury for largemouth bass and all species.

See tables E-29 and E-30 for the RAGS Part D Tables 7, E-61 and E-62 for the RAGS Part D Tables 9, and E-86 and E-87 for the RAGS Part D Tables 10 for the child recreational angler evaluation.

5.5.6.3 Adult

The total fish RME cancer risks for the adult angler for Knob Creek were greater than the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 2.5E-03 (carp), 2.7E-04 (largemouth bass) and 2.4E-03 (all species). The total fish CTE cancer risks for the adult angler for Knob Creek were greater than the EPA acceptable cancer risk range of 1E-06 to 1E-04 with total cancer risks of 6.3E-04 (carp), 6.7E-05 (largemouth bass) and 6.1E-04 (all species). The primary risk drivers were 2,3,7,8-TCDD TEQ, PCB dioxin-like congener TEQ, PCB-1260, arsenic, and chromium for carp, 2,3,7,8-TCDD TEQ, PCB dioxin-like congener TEQ, PCB-1260,

and chromium for largemouth bass, and 2,3,7,8-TCDD TEQ, PCB dioxin-like congener TEQ, PCB-1260, arsenic, and chromium for all species.

The total fish RME noncancer HIs for the adult angler for Knob Creek were greater than the noncancer benchmark with HIs of 45 (carp), 5.8 (largemouth bass), and 11 (all species). The total fish CTE noncancer HIs for the adult angler for Knob Creek were greater than the noncancer benchmark with HIs of 11 (carp), 2 (largemouth bass), and 11 (all species). The primary contributors to the total HI were 2,3,7,8-TCDD TEQ (carp and all species only), PCB dioxin-like congener TEQ, and PCB-1260 (carp), PCB Dioxin-like Congener TEQ, and mercury (largemouth bass and all species only).

See tables E-31 and E-32 for the RAGS Part D Tables 7, E-63 and E-64 for the RAGS Part D Tables 9, and E-88 and E-89 for the RAGS Part D Tables 10 for the adult recreational angler evaluation.

Tables 49R through 51 present a summary of COC exceedances (TR greater than 1E-06 and/or THQ greater than1.0) for soil, groundwater, fish tissue, and soil gas receptors, respectively.

5.6 CUMULATIVE RISKS

Table 53R presents the cumulative cancer risks and noncancer HIs across all media for both the on-site worker and resident receptors. The remaining receptors were not evaluated for more than one exposure medium and were therefore not included in the cumulative risk summary. As shown, all of the cumulative cancer risks and noncancer HIs for the on-site worker and resident exceeded EPA's acceptable cancer risk range and noncancer threshold of 1.

5.7 REMEDIAL GOAL OPTIONS

Remedial goal options (RGOs) are site-specific long-term numerical goals used during analysis of potential remedial alternatives. According to EPA guidance, once the HHRA has been performed, RGOs should be derived from the site-specific cancer risks and noncancer HQs (EPA, 2013a). RGOs were calculated using a risk ratio method based on site specific exposure concentrations, parameters, and dose equations. The ratio between the target risk (TR)/target hazard quotient

(THQ) and the calculated cancer risk noncancer hazard quotient (HQ) due to individual contaminants of potential concern (COPCs) in a specific medium used is as follows:

Exposure Point Concentration (EPC) Cancer Risk or Noncancer HQ = RGO TR or THQ

Rearranging this equation allows for the site-specific calculation of RGOs using the follow equation and assumptions:

RGO = EPC * TR or THQ Cancer Risk or Noncancer HQ

Where:

RGO = Media-specific remedial goal option (mg kg or µg L)

EPC = COPC- and medium-specific exposure point concentration (mg kg or µg L).

TR = 10-6, 10-5, or 10-4 cancer-based

THQ = 0.1, 1.0, or 3.0 noncancer-based

Cancer Risk = COPC- and medium-specific cancer risk based on residential exposure.

Noncancer HQ= COPC- and medium-specific hazard quotient based on residential exposure.

RGOs for soil based on residential land use are presented in Table 58. RGOs for soil based on commercial industrial land use are presented in Table 59. RGOs for groundwater based on residential land use may be found in Table 60R.

6. UNCERTAINTY ANALYSIS

The goal of an uncertainty analysis in a risk assessment is to provide to the appropriate decision makers (i.e., risk managers) information about the key assumptions, their inherent uncertainty and variability, and the impact of this uncertainty and variability on the estimates of risk. The uncertainty analysis shows that risks are relative in nature and do not represent an absolute quantification. The subsections that follow identify the major uncertainties inherent in the HHRA process by report section to determine if the calculated risks may have been overestimated or underestimated, and the approximate degree to which this may have occurred.

6.1 HAZARD IDENTIFICATION

- **Incorporation of data within on-site capped areas** – As mentioned previously, in order to fully characterize the on-site area, subsurface data within the on-site capped areas is incorporated in the HHRA evaluation. The capped area soil is unlikely to ever be available for exposure to human receptors and overestimates the human health risks associated with subsurface soil exposure to a significant degree.

- **Analytes without screening values** – A number of detected analytes did not have screening values available and were not carried through the risk assessment process. Because toxicity criteria were not available for these analytes (as demonstrated by a lack of health-based screening concentrations), risks (cancer and noncancer) could not be estimated. It is possible that site risks are underestimated as a result.

- **Risks from laboratory-related BEHP –** BEHP is a carcinogen and was identified as a groundwater COPC. However, BEHP is a common laboratory contaminant and it is highly unlikely that it is present in the shallow or deep groundwater at SMS site. BEHP exposure resulted in a total RME residential cancer risk of 2.9E-04 (21.2% of total cancer risk) and 8.4E-04 (50% of total cancer risk) for the shallow and deep groundwater respectively. Total BEHP HQs for the RME child resident were 4.8 (less than 1% of total HI) and 14 (4.0% of the total HI) for the shallow and deep groundwater, respectively. It is likely that the risks from BEHP are significantly overestimated and that it is not present in the SMS groundwater at levels of concern for human health.

- **Chromium evaluation** – Hexavalent chromium results for groundwater showed three hexavalent chromium detects out of nine samples. The detected hexavalent chromium concentrations were significantly less than those of total chromium, indicating that the total chromium samples are likely not largely comprised of hexavalent chromium. However, for conservatism, the toxicity and cancer risk characterizations for total chromium were evaluated through use of hexavalent chromium CSFs and URFs as presented on the EPA RSL table (EPA, 2015a). The use of hexavalent chromium CSFs and URFs to evaluate risks from exposures to total chromium presents a conservative approach that likely overestimates risks from total chromium.

- **Essential nutrients** – As discussed in Section 2.5, nutrient-based reference values for calcium, chloride, fluoride, nitrate, nitrite, sodium, and sulfate are significantly exceeded by site concentrations. Currently, site groundwater is not used for potable water and there are no plans for future potable use. Furthermore, it is evident that hypothetical future receptors would not be able to withstand drinking the water due to its high sodium levels. At 250 milligrams per liter (mg/L), the secondary MCL for chloride (EPA, 2009b), drinking water begins to taste salty. Site levels of 30,000 mg/L far exceed this level and would eliminate any future receptors from potentially ingesting tap water.

- **Inclusion of samples MW10A and MW10B** – Groundwater monitoring wells MW10A and MW10B collected in June of 2012 were initially determined to be a

background locations due to their proximity to the site as well as being up gradient of the site. However, analytical results indicated high levels of contaminants within these wells. Therefore, MW10A and MW10B were incorporated into the on-site groundwater evaluation and a new background location was established. Resampling of these wells occurred in December of 2012, June of 2013, November of 2013, and March of 2014. The uncertainty associated with the inclusion of these samples and their implications on site-related contamination is unknown and likely overestimates groundwater risks to human health receptors.

- **Modeling of indoor air concentrations** – Indoor air concentrations were modeled based on EPA's VISL Calculator using site soil gas data. Modeling any exposure medium presents a level of uncertainty. There are no buildings currently on-site for which to sample indoor air concentrations. It is unknown whether these modeling results over- or underestimate indoor air risks to potential future receptors.

6.2 EXPOSURE ASSESSMENT

- **The selection of exposure scenarios** – It is likely that the scenarios evaluated overstate realistic exposures, and thus overestimate the actual site risks. For example, the evaluation of a future residential scenario would significantly overestimate potential site risks given the current conditions and anticipated future land uses.

- **The selection of exposure assumptions** – The exposure assumptions directly influence the calculated doses (chronic daily intakes), and ultimately the calculation of risk. The RME concept was used to estimate the exposure potential for each of the receptors that were evaluated in the HHRA. The RME is defined as the "maximum exposure that is reasonably expected to occur at the site" (EPA, 1989). In most cases, these assumptions contribute to an overestimation of plausible real-life exposures, and a resulting overestimation of risk.

- **Fish exposure assumptions** – Due to a lack of site- or regional-specific fish ingestion rates, a default of 54 g/day was used for the adult angler (27 g/day for the child angler) per EPA Region 4 guidance (EPA, 2008). The use of 54 g/day is equivalent to approximately two 6 ounce meals per week from Knob Creek. Additionally, it was conservatively assumed that the anglers catch and consume all of their fish from Knob Creek. These assumptions are likely overestimates for a recreational angler and therefore overestimate the risks associated with the adult and child angler scenarios to a significant degree.

- **Fish tissue collection** – As presented in Figure 2-4, fish tissue samples were collected well downstream of the SMS site, as well as downstream from several other potential source areas shown in Figure 6-1, land use. Furthermore, Knob Creek is largely comprised of waters received from the Tennessee River, which is potentially another large source of contamination in Knob Creek fish tissue. Given the proximity of fish tissue samples to the SMS site, the proximity of other potential source areas, and the

contribution from the Tennessee River, risks associated with the fish consumption pathway are likely not entirely attributable to the SMS site.

- **Calculation of 95% UCLs** – As presented in Section 4.3.6, where appropriate, one-sided 95% UCLs were calculated and used as the EPC. A conservative approach of using the full detection limit for NDs was followed for all COPCs in this HHRA. The resulting value represents a conservative estimate of the COPC concentration to which an individual could be exposed in any given EA during the defined exposure duration and frequency. It is likely that using the full detection limit overestimates the site risk to some degree.

- **Use of maximum detected concentrations for EPCs** – As a conservative measure, in cases where there were not enough samples to calculate a UCL, the maximum detected concentration was assumed as the EPC. The ProUCL guidance indicates that the maximum detected concentration should never be used as it is not a central tendency term and is not relatable to how receptors contact media at the site. IThe use of maximum detected concentrations for the EPC significantly overestimates receptor risks.

6.3 TOXICITY ASSESSMENT

- **The use of CSFs and RfDs** – Both cancer risks and noncancer health effects were evaluated using EPA-approved or provisional toxicity criteria. The CSFs and RfDs are derived to be health protective and tend to overestimate true toxicity in humans. Therefore, risk calculations, which are partially based on toxicity estimates, may be overstated in general. The exact degree of overestimation cannot always be determined and each COPC must be evaluated on a case-by-case basis.

- **Lack of toxicity values for dermal exposure** – Toxicity values for dermal exposures have not been developed by EPA. Oral reference doses and CSF_os were adjusted and used to assess toxicity from dermal exposures following guidelines provided by EPA. The dermal route of exposure can result in different patterns of distribution, metabolism, and excretion than occur from the oral route. When oral toxicity values for systemic effects are applied to dermal exposures, uncertainty in the risk assessment is introduced because these differences are not taken into account. Since any toxicity differences between oral and dermal exposure would depend on the specific COPC, use of oral toxicity factors can result in the overestimation or underestimation of risk. It is not possible to make a general statement about the direction or magnitude of this uncertainty.

- **Dermal carcinogenicity of PAHs** – The majority of animal and human studies of PAH exposure strongly suggest that the carcinogenic effects resulting from exposure occur at the site of contact or administration (e.g., skin tumors from dermal contact, GI tumors from oral contact) (ATSDR, 1995). There is little evidence that PAHs produce systemic tumors following dermal contact (ATSDR, 1995). In order to justify the

extrapolation of a CSF_o to a CSF_d, an assumption must be made that the type of cancer produced by oral administration is the same as that which would be expected following dermal contact (i.e., that dermal contact with PAHs would produce GI tumors). Since this is not believed to be the case, even though dermal absorption has been quantified for PAHs, extrapolation of the CSF_o to the dermal route of exposure introduces a high level of uncertainty into the analysis. Although it is unlikely that GI tumors would be produced by dermal contact with PAHs, since there is evidence that dermal contact with PAHs may cause skin cancer, the only available data (i.e., the CSF_o) was used to quantify potential cancer risk from dermal contact with PAHs. This approach introduces a high degree of uncertainty into the analysis, and may overestimate the dermal cancer risks from PAHs to a significant degree.

7. RISK SUMMARY

7.1 SOIL

As presented in Table 54, the majority of carcinogenic risks were below the EPA acceptable cancer risk range of 1E-06 to 1E-04 and the majority of noncancer HIs were below the EPA noncancer benchmark of 1.0. The on-site RME residential scenario slightly exceeded the EPA acceptable levels for chromium (cancer risk of 1.2E-04) and thallium at Flenniken Branch slightly exceeded the EPA acceptable level (noncancer HI of 1.4). As discussed previously, chromium levels are likely overestimated due to the conservative use of hexavalent chromium toxicity values. The thallium total HI of 1.4 is slightly above the noncancer benchmark. Given that the overall approach to the HHRA would tend to overestimate actual risks to a fairly significant degree, it is unlikely that soil exposure at the SMS site would result in any unacceptable health impacts for the evaluated soil receptors.

7.2 GROUNDWATER

As presented in Table 55, several shallow groundwater COPCs had total RME cancer risks or total HIs in exceedance of EPA's acceptable criteria, including BEHP, aluminum, arsenic, chromium, cobalt, manganese, mercury, molybdenum, nickel, thallium, and zinc. Similarly, deep groundwater COPCs with total RME cancer risks or total HIs in exceedance of EPA's acceptable criteria include BEHP, arsenic, cobalt, cyanide, manganese, molybdenum, and thallium. As discussed previously in the Uncertainty Analysis, risks associated with BEHP are likely due to laboratory contamination and not attributable to site-related contamination. Similarly, risks

associated with chromium are likely overestimated due to the use of hexavalent chromium toxicity values. Contributions from MW10A and MW10B, as discussed previously, further overestimate site groundwater risks. The majority of shallow groundwater risks are driven by the initial round of sampling from MW10A including aluminum, arsenic, cobalt, manganese, mercury, nickel, thallium, and zinc. The deep groundwater COPCs being driven by the first round of sampling from MW10B include BEHP.

Additionally, vapor intrusion of 1,2,4-trimethylbenzene, benzene, bromomethane, chloroform, ethylbenzene, naphthalene, tetrachloroethane, TCE, and cyanide could be a concern for potential future receptors. However, as stated previously, exceedances for 1,2,4-trimethylbenzene, benzene, bromomethane, and naphthalene only slightly exceed a ratio of 1 and are likely not a concern for vapor intrusion. Furthermore, the exceedances for the remaining VOCs are based on concentrations from wells located within the waste pile area (MW01A and MW 02A).

Shallow and deep groundwater cancer risks and noncancer HQs are also driven by samples located within the capped waste pile area including MW08A, MW07B, MW02A, and MW03B or downgradient of the waste pile area (MW11B).

Although site groundwater risks are likely overestimated for a number of reasons stated previously, there is still the potential that groundwater exposure to the above COPCs at the SMS site would result in unacceptable health impacts primarily for the future resident and to a lesser degree, the future on-site worker. It should be noted however that future groundwater use is unlikely at the SMS site. A hypothetical future residential scenario was only evaluated to determine an upper-bound estimate of site risks and the majority of groundwater risks are being driven by the conservative residential evaluation.

As discussed in Section 5.3, EPA's IEUBK model estimated that the geometric mean blood lead concentration among future residential children exposed to shallow groundwater would be less than EPA's established level of concern and the probability that the child's blood lead concentration exceeds 10 µg/dL would be less than 5% for both shallow groundwater. Although the deep groundwater shows a geometric blood lead level less than 10 µg/dL, there is a greater than 5% probability that a child's blood lead concentration exceeds 10 µg/dL. Therefore,

exposures to lead are not a concern in shallow groundwater, but may be of concern from deep groundwater at the SMS site.

7.3 FISH

Table 56 presents those COPCs in fish tissue with RME total cancer risks exceeding EPA's acceptable cancer risk range or total HIs exceeding EPA's noncancer benchmark. These COPCs include 2,3,7,8-TCDD TEQ, PCB dioxin-like congener TEQ, PCB-1260, chromium, and mercury. As discussed in the Uncertainly Analysis, risks associated with the child and adult anglers is likely overestimated due to the use of the conservative ingestion rate and fraction ingested used, the proximity of other potential source areas, and the contribution from Tennessee River. Fish ingestion risks are likely not entirely attributable to site-related activities at SMS. However, taking into account this and other conservative assumptions in the HHRA, there is still the potential for adverse health impacts to child and adult anglers at Knob Creek for the above COPCs.

7.4 SOIL GAS

Table 57 presents those COPCs in soil gas with RME total cancer risks exceeding EPA's acceptable cancer risk range or total HIs exceeding EPA's noncancer benchmark. These COPCs include 1,1-dichloroethane, 1,2-dichlroethane, and chloromethane. As discussed in the Uncertainly Analysis, risks associated with the soil gas pathway is likely overestimated due to the modeling of indoor air concentrations, rather using actual indoor air sampling results. However, taking into account this and other conservative assumptions in the HHRA, there is still the potential for adverse health impacts to potential future on-site workers and hypothetical future residents for the above COPCs. It should be noted that there are currently no buildings on-site and future development is not anticipated. In the event that future development occurs at the SMS site, the vapor intrusion pathway will need to be revisited.

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Table 4R-1
Occurrence, Distribution, and Selection of Contaminants of Potential Concern - Fish Tissue
Smokey Mountain Smelters
Knoxville, Tennessee

Scenario Timeframe: Current/Future
Medium: Fish
Exposure Medium: Fish Tissue

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (n/c) (2)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
[illegible] Creek - Carp	[illegible]	Benzaldehyde	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	NA	NA	No	BSL
	[illegible]	[illegible] Heptachlorodibenzodioxin	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Heptachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Hexachlorodibenzodioxin	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Hexachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Hexachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Hexachlorodibenzodioxin	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Pentachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Pentachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Tetrachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible]chlorodibenzodioxin	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
		[illegible] TCDD TEQ	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	1,1'-Biphenyl, [illegible] heptachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	1,1'-Biphenyl, [illegible] hexachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	1,1'-Biphenyl, [illegible] pentachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #105	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #1[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #1[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #1[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #1[illegible] and/or 15[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #1[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
		PCB Dioxin-like congener TEQ	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	PCB-1[illegible]	[illegible]	1	mg/kg	[illegible]	[illegible]	NA	1	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	Aluminum	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Arsenic	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	Barium	[illegible]	1	mg/kg	[illegible]	[illegible]	NA	1	NA	1 n	NA	NA	No	BSL
	[illegible]	Calcium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Chromium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	Copper	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Iron	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Lead	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible] n	NA	NA	YES	ASL
	[illegible]	Magnesium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Manganese	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Nickel	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	1 n	NA	NA	No	BSL
	[illegible]	Potassium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Selenium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Sodium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Strontium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Zinc	[illegible]		mg/kg	[illegible]	[illegible]	NA		NA	[illegible] n	NA	NA	No	BSL
[illegible] Creek - Largemouth Bass	[illegible]	[illegible] Heptachlorodibenzodioxin	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Hexachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Hexachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
	[illegible]	[illegible] Tetrachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as [illegible] TCDD TEQ				
		[illegible] TCDD TEQ	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	1,1'-Biphenyl, [illegible] heptachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	1,1'-Biphenyl, [illegible] hexachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	1,1'-Biphenyl, [illegible] pentachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #105	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #1[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #1[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				

Table 4R-1
Occurrence, Distribution, and Selection of Contaminants of Potential Concern - Fish Tissue
Smokey Mountain Smelters
Knoxville, Tennessee

Scenario Timeframe: Current/Future
Medium: Fish
Exposure Medium: Fish Tissue

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (n/c) (2)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Knob Creek - Largemouth Bass [illegible]	[illegible]	PCB congener #126	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #156 and/or 157	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #169	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #77	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
		PCB Dioxin-like congener TEQ	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	PCB-1260	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	Barium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	1 n	NA	NA	No	BSL
	[illegible]	Calcium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Chromium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	Copper	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Iron	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	110 n	NA	NA	No	BSL
	[illegible]	Magnesium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Mercury	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible] n	NA	NA	YES	ASL
	[illegible]	Nickel	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	1 n	NA	NA	No	BSL
	[illegible]	Potassium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Selenium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Sodium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Strontium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Zinc	[illegible]	11	mg/kg	[illegible]	[illegible]	NA	11	NA	[illegible] n	NA	NA	No	BSL
Knob Creek - All Species	[illegible]	Benzaldehyde	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	15 n	NA	NA	No	BSL
	[illegible]	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	1,2,3,4,6,7,8-Heptachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	1,2,3,4,7,8-Hexachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	1,2,3,6,7,8-Hexachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	1,2,3,7,8-Pentachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	2,3,4,7,8-Pentachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	2,3,7,8-Tetrachlorodibenzofuran	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
	[illegible]	Octachlorodibenzo-p-dioxin	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	Evaluated as 2,3,7,8-TCDD TEQ				
		2,3,7,8-TCDD TEQ	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	1,1'-Biphenyl, 2,2',3,4,4',5,5'-heptachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	1,1'-Biphenyl, 2,3,3',4,4',5,5'-hexachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	1,1'-Biphenyl, 2,3',4,4',5-Pentachloro	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #105	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #11[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #1[illegible]	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #126	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #156 and/or 157	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #169	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
	[illegible]	PCB congener #77	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	Evaluated as PCB TEQ				
		PCB Dioxin-like congener TEQ	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	PCB-1260	[illegible]	1	mg/kg	[illegible]	[illegible]	NA	1	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	Aluminum	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	150 n	NA	NA	No	BSL
	[illegible]	Arsenic	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	Barium	[illegible]	1	mg/kg	[illegible]	[illegible]	NA	1	NA	1 n	NA	NA	No	BSL
	[illegible]	Calcium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT
	[illegible]	Chromium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible]	NA	NA	YES	ASL
	[illegible]	Copper	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible] n	NA	NA	No	BSL
	[illegible]	Iron	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	110 n	NA	NA	No	BSL
	[illegible]	Lead	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	[illegible]	[illegible]	NA	[illegible] n	NA	NA	YES	ASL
	[illegible]	Magnesium	[illegible]	[illegible]	mg/kg	[illegible]	[illegible]	NA	[illegible]	NA	NUT	NA	NA	No	NUT

Table 4R-1
Occurrence, Distribution, and Selection of Contaminants of Potential Concern - Fish Tissue
Smokey Mountain Smelters
Knoxville, Tennessee

Scenario Timeframe: Current/Future Medium: Fish Exposure Medium: Fish Tissue

Exposure Point	CAS Number	Contaminant	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value	Screening Toxicity Value (n/c) (2)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion
Knob Creek - All Species composite	7439-96-5	Manganese	1.4	4	mg/kg	SMSFT-0[illegible]	5/12	0.9 - 1.1	4	NA	[illegible] n	NA	NA	No	BSL
	7439-97-6	Mercury	0.1	0.29	mg/kg	SMSFTB05	5/12	0.004 - 0.2	0.29	NA	0.015 n	NA	NA	YES	ASL
	7440-02-0	Nickel	0.27	0.5	mg/kg	SMSFTB01	2/12	0.17 - 0.2	0.5	NA	1 n	NA	NA	No	BSL
	7440-09-7	Potassium	[illegible]000	[illegible]900	mg/kg	SMSFT-01, SMSFT-02, SMSF[illegible]	12/12	NA	[illegible]900	NA	NUT	NA	NA	No	NUT
	7782-49-2	Selenium	0.19	0.59	mg/kg	SMSFT-0[illegible]	12/12	NA	0.59	NA	0.77 n	NA	NA	No	BSL
	7440-23-5	Sodium	510	770	mg/kg	SMSFT-05	12/12	NA	770	NA	NUT	NA	NA	No	NUT
	7440-24-6	Strontium	1.9	5.6	mg/kg	SMSFT-05	12/12	NA	5.6	NA	9 n	NA	NA	No	BSL
	7440-66-6	Zinc	6.9		mg/kg	SMSFT-0[illegible]	12/12	NA		NA	46 n	NA	NA	No	BSL

Note / Source:

(1) Maximum detected concentration used for screening.

(2) Risk-based residential fish concentration obtained from the Regional Screening Level (RSL) Fish Ingestion Table (November 2014).

Surrogate screening values used:

Methyl mercury value used for mercury

Hexavalent chromium used for chromium

c = cancer-based screening value at a target risk of 1E-06

n = noncancer-based screening value at a target hazard quotient of 0.1

ASL = above screening level

BSL = below screening level

c = cancer-based screening value at a target risk of 1E-06

NA = not available

NBA = No benchmark available

n = noncancer-based screening value at a target hazard quotient of 0.1

NUT = essential nutrient

ASL = above screening level

BSL = below screening level

NSA = no screening benchmark available

Table 60R-1
Summary of Groundwater Remedial Goal Options - Residential Use of Groundwater
Smokey Mountain Smelters
Knoxville, Knox County, Tennessee

Chemical of Concern[2]	Groundwater Depth	Groundwater Remedial Goal Options[1] (units in µg/L)						MCL[3] (µg/L)
		Cancer-Based			Noncancer-Based			
		1E-06	1E-05	1E-04	0.1	1	3	
Aluminum	Shallow	NA	NA	NA	1,997	19,967	59,900	NA
Ammonia	Shallow	NA	NA	NA	NA	30,000 [4]	NA	NA
Arsenic	Shallow, Deep	0.05	0.5	5	0.6	6	18	10
Chromium	Shallow, Deep	0.04	0.4	4	NA	NA	NA	100
Cobalt	Shallow, Deep	NA	NA	NA	0.6	6	18	NA
Fluoride	Shallow	NA	NA	NA	NA	NA	NA	4,000
Manganese	Shallow, Deep	NA	NA	NA	43	433	1,300	NA
Mercury	Shallow	NA	NA	NA	0.6	6	17	2
Nickel	Shallow	NA	NA	NA	39	392	1,177	NA
Nitrate/Nitrite	Shallow	NA	NA	NA	NA	NA	NA	10,000
Pentachlorophenol	Shallow, Deep	0.2	2	21	10	100	301	1
Thallium	Shallow, Deep	NA	NA	NA	0.02	0.2	0.6	2
Zinc	Shallow	NA	NA	NA	600	6,001	18,002	NA

Notes

[1] RGOs based on RME residential exposure assumptions.

[2] Per EPA Region 4 guidance, carcinogenic chemicals of concern (COCs) selected based on risks in exceedance of 1E-04. Noncancer COCs selected based on HQs in exceedance of 1 and/or contributing to target organ-specific HIs greater than 1.0 (EPA, 2000).

[3] MCL - Maximum contaminant level

[4] EPA Lifetime Health Advisory

NA - Not applicable